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SYMPOSIUM

Screening for Asymptomatic Disease

Special Editors

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INTRODUCTORY STATEMENT ON SCREENING FOR ASYMPTOMATIC DISEASE

PROGRESS in reducing the disability resulting from many chronic diseases is dependent in large measure on *early* diagnosis and treatment. In the practice of medicine it is commonplace to be faced with patients who for one reason or another have gone untreated for a prolonged period and whose disease has passed the point at which a satisfactory response to therapy can be anticipated. Nursing homes and chronic disease hospitals are filled largely with patients in whom the disease process has done its damage and for whom no definitive treatment can be expected to result in substantial curative as opposed to symptomatic improvement. Yet many patients would not have reached such advanced states of illness if the chronic disease from which they suffer had been diagnosed early and brought under adequate treatment.

The problem then is: How to narrow the time gap between the onset of a disease and its diagnosis? To what extent is it possible and practical to diagnose asymptomatic or "nonmanifest" disease? In the normal course of office medical practice, some nonmanifest disease is detected. An increasing (yet small) group of physicians in general practice encourage their patients to come in for a periodic health examination. The physician who in obstetrical cases routinely obtains a chest x-ray and serologic test for syphilis is rewarded from time to time by detecting unsuspected disease. As a group, the pediatricians have probably gone furthest in developing the techniques and pattern of practice directed to-

ward early detection of minor deviations from normal (supervision of the "well" infant and child) that may be of importance to the subsequent health of the patient.

Early detection of asymptomatic disease through office practice appears to be substantially limited by three factors:

1. If a physician's examination of a presumably well person is to be useful, it must be thorough, fairly detailed, and supplemented by selected x-ray and laboratory tests. Such examinations are expensive.
2. The great bulk of the population goes to a physician only for the diagnosis and treatment of manifest illness. Except for persons in the upper income brackets who are perhaps more sophisticated in health matters, the American people do not seem impressed with the value of periodic health examinations.
3. A large number of physicians have neither the time for nor the interest in examining well adults. They are overtaxed by meeting the demands of acutely and chronically ill patients and all too often deal as briefly as possible with the person seeking a health examination whom they may regard as "probably neurotic."

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Several other approaches to early diagnosis of silent disease have been developed, each of which has strong and weak features. The general public is now familiar with the mass chest x-ray surveys using mobile photofluorographic units. Cancer detection clinics, annual diabetes detection drives, school health examinations, routine insurance and employment examinations, are all well-known examples of different administrative approaches to detection of nonmanifest disease. The last decade has seen development of multiphasic screening in which a battery of screening tests is applied to large population groups and the results are sent to the patient's physician. Such programs have been operated, practically always on an episodic demonstration basis, by health departments, hospitals, unions, and medical societies. It is important that the strengths and weaknesses of each of the available approaches to early detection of disease be evaluated objectively. This will necessarily involve a consideration of the reliability and cost of the methods employed, the ease with which procedures can be widely applied to large numbers of persons, and the acceptability of procedures to the patient, the physician, and the community.

This issue of the JOURNAL OF CHRONIC DISEASES is devoted to the broad subject of "Screening for Asymptomatic Disease" as applied in a wide variety of settings including the schools, industrial plants, and health departments. The articles have been prepared by authors with vastly different backgrounds and reflect their different points of view. In order that the different papers might have some common ground, at least in the use of certain terminology, the authors were urged to observe the following definitions which were adopted by the Conference on Preventive Aspects of Chronic Disease.*

*Conference on the Preventive Aspects of Chronic Disease. Sponsored by the Commission on Chronic Illness, March 1951, Chicago, Ill. Proceedings published by Health Publications Institute, Inc., Raleigh, N. C. (311 pages).

Chronic disease comprises all impairments or deviations from normal which have *one or more* of the following characteristics: (a) are permanent; (b) leave residual disability; (c) are caused by nonreversible pathologic alteration; (d) require special training of the patient for rehabilitation; or (e) may be expected to require a long period of supervision, observation, or care.

Prevention, in its narrowest sense, means averting the development of a pathologic state; more broadly, it includes also all measures which halt progression of disease to disability or death.

a. *Primary prevention* means averting the occurrence of disease. Example: Preventing the occurrence of lung cancer by protecting individuals from exposure to chromate dust.
b. *Secondary prevention* means halting the progression of a disease from its early unrecognized stage to a more severe one and preventing complications or sequelae of disease. Examples: (1) Preventing late pulmonary tuberculosis and its complications by detecting, diagnosing, and treating preclinical stages of pulmonary tuberculosis. (2) Preventing subacute bacterial endocarditis in persons with rheumatic or congenital heart disease by prophylactic antibiotic therapy during periods of maximum risk.

Detection is the *identification* of ordinarily unrecognized disease or defect by the application of screening tests, examinations, and diagnostic procedures.

Screening is the *presumptive identification* of unrecognized disease or defect by the application of tests, examinations, or other procedures which can be applied rapidly. Screening tests sort out apparently well persons who probably have a disease from those who probably do not. A screening test is not intended to be diagnostic. Persons with positive or suspicious findings must be referred to their physicians for diagnosis and necessary treatment.

Screening tests are procedures which sort out those who probably have abnormalities from those who probably do not.

Mass screening programs consist of the application of screening tests rapidly and economically to large population groups, to identify those who probably have abnormal conditions and to refer them for diagnosis and, if indicated, for further medical care. The primary purpose of mass screening is to bring persons with disease to physicians at an earlier stage than otherwise would be the case.

Validity of a screening test. The validity of a test is measured by the frequency with which the result of the test is confirmed by an acceptable diagnostic procedure. Four possibilities exist when the results of the screening test are compared with those of the diagnostic tests:

a. "True positives"—those who are selected by the screen and are also found to be positive by the diagnostic procedure.
b. "False positives"—those selected by the screen who are found to be negative by the diagnostic procedure.

c. "True negatives"—those who are not selected by the screen and are found to be negative by the diagnostic procedure.
d. "False negatives"—those not selected by the screen but found to be positive by the diagnostic procedure.

The previous statement was sent as a "frame of reference" to the authors of the papers in this issue.

As the material of this issue has accumulated, it has become clear that screening programs, while they have accomplished a great deal of good, have not fully met their early promise, probably because of:

1. The general absence of a continuing (as opposed to an episodic or a demonstration) facility for multiphasic screening.
2. The general absence of practicing physicians' interest and participation.
3. Lack of agreement as to which procedures should be incorporated into a screening program for general and special population groups. This disagreement is at least in part based on the following:
4. Lack of accurate knowledge of the yield of disease to be expected from particular screening procedures.
5. Cost.

The series of articles herewith presented provide food for subsequent thought as to how to meet these deficiencies. It is the intention of the Editors to stimulate further discussion of the problems raised.

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SCREENING FOR ASYMPTOMATIC DISEASE

Principles and Background

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THAT disease can be discovered before it produces recognizable symptoms has long been known and accepted in the practice of medicine. The final diagnosis that disease is present, and the decision as to what should be done about it, is a responsibility which can be assumed legally only by a person licensed to practice medicine. The process of discovering asymptomatic disease is generally termed detection.[1] Screening is a preliminary step toward detection. Definitions of screening and detection were adopted by the Conference on Preventive Aspects of Chronic Disease, convened by the Commission on Chronic Illness in March, 1951, and have been presented in the Introductory Statement to this symposium.

Since symptom-producing disease does not preclude the presence of other disease, screening for asymptomatic disease can be carried out among the sick as well as among the presumably well population. Routine serologic tests for syphilis and photofluorographic chest x-rays of patients admitted to hospitals are well established, though far from generally practiced, examples of screening applied to the sick. There is little question of the desirability of extending this type of screening to include other procedures which satisfy criteria of reliability and practicability. Examples of screening procedures applied to the "well" population, which have been widely utilized and accepted, include routine examination of school children for visual and other defects, serologic tests for syphilis, and photofluorographic chest x-rays for pulmonary tuberculosis, other pulmonary disease, and heart disease. Periodic health examinations often include a number of screening tests, performed by technicians or other nonmedical personnel.

Since screening tests are not definitive diagnostic procedures, it is assumed that, except for survey and investigative purposes, they are not considered ends in themselves, but only a means of identifying persons regarding whom the probability of the presence or absence of the disease in question is high, with definitive diagnostic procedures applied to the former. Although no screening test, or indeed diagnostic test, is infallible, it is possible in some instances to set the standard of the test so that either the positive or the negative decision has a probability that is close to 100 per cent. Usually this is accompanied by a corresponding decrease in the accuracy of the opposite decision. Thus, a test of high sensitivity usually means one in which there will be a relatively high per cent of false positives, with few false negatives.

Two basic assumptions implied in advocating the discovery of asymptomatic chronic disease are: (1) that asymptomatic disease is more likely to be pathologically "early," and (2) that "early" disease is more amenable to control by suitable treatment. Although these assumptions are reasonable, they are not beyond the need for objective proof and measurement. It is known that both assumptions may be incorrect in individual instances of some chronic diseases.

There has been considerable discussion regarding the advisability of applying tests for several rather than for one disease. In 1953, the American Medical Association's Council on Medical Science issued "A Study of Multiple Screening"[2] in which the results of 22 multiple screening surveys were reviewed, together with an introductory discussion of the literature.

This report describes multiple screening projects carried out from April, 1946, to November, 1952. The report describes six California projects and five Boston projects, as well as projects in Alabama, Virginia, Florida, Indianapolis, New Orleans, North Carolina, and Pennsylvania. In Alabama, over 500,000 persons received multiple screening tests in less than seven months. In Georgia, over a three-year period, over 500,000 persons were screened. In Richmond, Virginia, 38,000 persons were given nine screening tests during the seven-month period of operation of a project sponsored and conducted by the Richmond City Department of Health, the Richmond Area Community Council, the U. S. Public Health Service, and a number of other state and local health agencies. This project was the subject of a special study conducted by Walter E. Boek for the Health Information Foundation.[3] The earliest projects reported were one in New Orleans, as part of a cancer detection project, which began in April, 1946, and another conducted in Central and Western Pennsylvania in October, 1946, by the Industrial Ladies Garment Workers Union. One of the first projects reported in the literature was that conducted in 1948 in San Jose, California, by the Santa Clara County Medical Society, the San Jose City Health Department, and the California Department of Health.[4]

The subject of screening and multiple screening was extensively reviewed and discussed also by the Conference on Preventive Aspects of Chronic Disease (Commission on Chronic Illness), March 12-14, 1951.[5] Four of the twelve working committees confined their attention to "Early Detection and Screening." The wide representative character of the Conference and the comprehensive discussions embodied in the working committee reports and other documents presented in the Conference Proceedings make this a valuable source for material on the principles and problems of screening for asymptomatic disease.

Criteria for determining suitability of screening procedures were considered by the Committees on Early Detection and Screening of Section IV (Community Organization and Services) and of Section I (Evaluation of Scientific Data) of the Conference. The former committee* proposed the following 10 criteria "to be used in determining the suitability of a screening procedure for community use:

*Chairman: Dr. Lester Breslow; Recorder: Dr. C. Howe Eller.

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"1. Scientific validity of the procedure;
"2. Acceptability to the individual being screened;
"3. Acceptability to the professional groups concerned;
"4. Productivity of the procedure, i.e., the amount, and social and economic significance, of previously unknown disease likely to be detected;
"5. Cost, including accessibility of the population to be screened, time required for the test, physical facilities required, and personnel required;
"6. Extent to which the procedure may be useful in screening for several diseases;
"7. Compatibility of the tests included in the procedure with the purpose of the screening procedure, i.e., the discovery of disease;
"8. Feasibility of properly interpreting to the public the need for screening, the results of screening, and the limitations of screening;
"9. Amenability to treatment of the disease conditions detected;
"10. Availability of adequate follow-up, including diagnostic and therapeutic care to all social and economic classes of persons in which disease is detected (lack of facilities for ultimate care should not be considered a bar to a screening program, provided there is a possible willingness on the part of the community to deal with needs revealed by the screening procedures)."

Committee B* of Section I of the Conference discussed the criteria of reliability, validity, yield, cost, and acceptance of screening tests in some detail and concluded that the first four of these were essential for the evaluation of screening tests and programs.

The Committee defined *reliability* as "reproducibility of results" of the testing procedure and pointed out that a test of reliability under closely controlled laboratory conditions should be followed by a second test under field conditions.

Validity was defined as "the frequency with which the result of the test is confirmed by an acceptable diagnostic procedure." Although the first step in measuring validity is determining the percentage of true and false positive and negative tests, the Committee commented that "these results are then related to the 'limits of tolerance' imposed by such factors as the incidence and prevalence of the disease, the expense of diagnosis, the psychological factors involved in incorrectly labeling an individual as positive and the false reassurance resulting from falsely labeling an individual as negative." The Committee commented that "the 'limits of tolerance' vary so widely among diseases that no general statements can be made at this time; however, it is of the greatest importance that careful studies be performed for the measurement of the importance of these factors in each chronic disease."

*Chairman: Dr. David D. Rutstein; Recorder: Dr. Antonio Ciocco.

"The validity of any particular test cannot be determined from . . . one . . . survey. Special studies . . . must be conducted for this particular purpose. Determination of validity . . . proceeds in the same two stages as the determination of reliability—first the 'laboratory' stage and then the 'field trial.' In the laboratory stage, the number of false negatives is most economically determined as a first approximation by using the test upon a group of positives previously established by some standard method. If the laboratory results are favorable, a field trial should be performed. At this stage, the only way of determining the number of false negatives is by complete examination of a representative sample of those labeled 'negative' by the screening test."

In discussing measurements of the "*yield* of a screening program" the Committee suggested the following: (a) number of previously unknown verified cases of disease, (b) number of such cases benefited by referral to medical care, (c) number of previously known cases benefited by return to medical care, (d) number of persons who had previously believed they had the disease and were shown not to have the disease, and (e) number of persons with communicable disease prevented from spreading the disease.

The Committee suggested also that *cost* evaluation be made by studies on cost accounting and job analysis conducted in connection with the screening programs. "Cost must be measured in monetary terms and in . . . time of professional and nonprofessional personnel." The Committee urged that screening tests and programs use a minimum of professional time and a maximum of the time of technicians and other nonprofessional personnel. The Committee pointed out that monetary cost could be considered: "(a) per test, (b) per case found, (c) per new case found," without indicating whether it considered any of these preferable to the others.

Regarding the fifth criterion, that of *acceptance*, the Committee's report discussed measurement of acceptance by individual laymen, physicians, and the community. It suggested, as a matter of measuring layman acceptance, "the proportion of the population which offers itself for screening, and . . . the proportion which accepts the results of the test and follows recommendations." The Committee suggested that the number of new patients referred to physicians might serve as a measure of physician acceptance. Community acceptance could be measured "by the degree of responsibility taken by official and voluntary community agencies to increase funds and facilities for care of patients discovered by the screening program and by the spirit with which the community undertakes subsequent screening programs."

The Committee report then touched on the need for special studies on the interval after which screening tests should be repeated "to assure maximum effectiveness" and suggested that screening programs may give more favorable results when applied to special population groups "where . . . high yields may result."

With respect to multiple screening, the Committee's report states, "The evaluation of a multiple screening program is in principle no different from that of a screening program for a single disease. Each of the component tests must be evaluated in accordance with the above criteria. In addition, special studies

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are needed to determine whether a particular multiple screening program increases or decreases the effectiveness of the individual component tests, and whether the multiple screening program is more effective than a series of individual screening programs."

The Committee on Early Detection and Screening of Section II, Prevention in Medical Practice,* stressed "the tremendous importance of the practicing physician in any program of screening." Screening programs were considered by the Committee to be "an auxiliary to the practicing physician" which would "conserve professional resources and time and increase the likelihood that physicians' care will be used by the greatest number . . . at the time when it will benefit them [the patients] most." The Committee suggested a number of procedures to be added to multiple screening, including self-recorded or technician-administered history, audiometry, tonometry, blood sedimentation rate, and, in "selected age groups," vaginal cytologic smears and electrocardiograms.

Since the proof of the screening pudding is in what happens afterwards, the principles regarding follow-up procedures proposed by the Committee on Early Detection and Screening (Community Organization and Services Section) are of great interest.

The Committee recommended the following principles:

"1. The medical profession should participate fully in planning for screening programs and should devote particular attention to secondary screening, referral for diagnosis, and other follow-up procedures.

"2. Secondary screening—defined as a procedure which is necessary following the primary screening, but before final diagnostic work-up—should be reduced as far as possible in order to minimize the number of patients who withdraw during a multiplicity of procedures and to minimize the delay in placing the patient under medical supervision.

"3. Under some circumstances, however, secondary screening is essential in order to reduce the number of suspected but ultimately unconfirmed cases, before referral for diagnosis; improve the chances of obtaining a diagnosis more quickly and accurately; or provide for the physician diagnostic resources which might not otherwise be available to him.

"4. The patient should be referred to an appropriate source of medical care. Usually this means referral to a physician of the patient's choice. Referral to a specialist should be considered a second step, to be decided upon by the patient's own physician.

"5. Care should be arranged for all groups of the population including those that might require special attention because of social, financial, legal, or residency problems. Each person screened should have adequate follow-up, irrespective of his ability to pay for it.

"6. Arrangements should be made to assist the patient and his family in meeting the psychological and social problems involved in follow-up.

*Chairman: Dr. Martin Cherkasky; Recorder: Dr. Edward M. Cohart.

"7. The evaluation of a screening program should be based not on the number of suspected cases found, but on the number ultimately diagnosed and treated."

This Committee also discussed the importance of participation by many community groups in screening programs, including professional groups (medicine, dentistry, nursing, social work, education, planning), health agencies, welfare agencies, educational agencies, civic organizations, organized labor, farm groups, clubs, and religious organizations. Two of the Committee's* recommendations are particularly pertinent with respect to interrelationship between community groups:

"6. That screening and detection procedures should routinely be made available to persons served by hospital, school health, out-patient department, industrial health, medical care programs, and other health services whenever feasible.

"7. That in developing screening and detection programs consideration be given to the feasibility of coordinating several programs through multiple screening in the interest of more adequate service."

A careful review of the reports of the various committees of the Conference indicates general agreement with the principle that multiple screening for asymptomatic disease is a desirable health service. The Committee on Public Education for Early Detection and Screening outlined a number of "obstacles that may confront" such a program.

"1. Budgetary difficulties.

"2. Traditions of medical practice.

"3. Lack of confidence in screening techniques.

"4. Creation of a demand for services after screening which cannot be fulfilled.
[The Committee on Early Detection and Screening, Community Organizations and Services was of the opinion that "lack of facilities for ultimate care should not be considered a bar to a screening program, provided there is a probable willingness on the part of the community to deal with needs revealed by the screening procedures."]

"5. Lack of cooperation between community health and welfare agencies, both voluntary and official, civic groups, labor unions, employers, etc.

"6 Apathy, inertia,reluctance to disturb the 'status quo.'

"7. Lack of trained personnel and adequate facilities for operation.

"8. Lack of organized health and social services for follow-up.

"9. Geography, e.g., rural populations.

"10. Lack of valid screening procedures for some diseases.

"11. Higher priority for other programs, e.g., civil defense.

*Chairman: Dr. Granville W. Larimore; Recorder: Dr. Claire Ryder.

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[If meeting today, the Committee probably would have added polio vaccine.]

"12. Administrative difficulties in handling a multiple screening program where it might be possible to handle a screening program for a single disease."

The Committee's report goes on to warn against possible misconceptions on the part of the public regarding screening which an educational program should try to avoid. Among these are: expecting definitive diagnosis or treatment; considering negative results as indicating "perfect health"; and not being prepared for false positive or false negative tests.

The Committee report then outlines what is in effect a blueprint for action in developing an educational program for screening. The first step suggested is the consideration of the problem by community leaders, from official and voluntary health agencies, the medical and allied professions, and consumer groups. The Committee remarks, "The route may be from the official health agency to the consumer groups or vice versa. Voluntary agencies should pool their services and facilities so that their individual interests may serve the overall problem of multiple screening." The second step is the formation of a project committee, selected from the groups mentioned above. One of the subcommittees should be on education which "will in general work with and through all available agencies and make use of all available educational media."

Prospects for Screening Programs.—A review of the discussions of the Conference suggests that the future development and extent of application of screening for asymptomatic disease probably depends as much on removing some of the obstacles outlined by the Committee on Public Education for Early Detection and Screening (see previous list) as on other factors. There is ample evidence that both single and multiple screening projects are well accepted by large numbers of the populations to which they are offered. The data reviewed in the report on screening made by the Council on Medical Service of the American Medical Association[2] support this conclusion. This might be termed a condition of potential acceptance of screening programs by the public. This is obviously not the same as active demand by the public, or by community leaders. Active demand depends on many factors including information and stimulation. It is important also that even in the presence of active public demand, there coexists also acceptance by professional and consumer group leaders who might be in a position to veto action to meet public demand. Experience on the interval between the development and widespread application of screening procedures for syphilis and tuberculosis would suggest that many years may elapse before screening procedures are utilized widely. Modern interest and publicity regarding health and medicine may shorten this interval in the future. It seems fairly certain that, as professional acceptance increases, screening for asymptomatic chronic disease will be applied to increasingly larger segments of the adult population.

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MULTIPHASIC SCREENING IN CALIFORNIA

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SEVEN years have now passed since the first multiphasic screening project in San Jose, California.[1,2] During the interval 16 such projects have been conducted in California with some assistance from the State Department of Public Health. In addition, several programs have been carried out in the state without such assistance. Many other states and communities have also initiated multiphasic screening.

It is desirable to review the experience in one state in order to evaluate what has been accomplished, and to examine some of the issues which have been raised about this new technique in health service.

This review will be limited to the 16 projects which the State Department of Public Health aided through financial assistance, loan of equipment, or consultation. In all instances some local health agency—a health department, voluntary health organization, industrial or school health service—took the primary responsibility for administration. County medical societies have given indorsement, advice on the policy, and sometimes assistance in actual administration. In a few instances, for example, where screening was limited to a student group or to employees in certain plants and provided by the medical agencies responsible for care of the group, county medical societies were not involved.

Approximately 100,000 Californians have received this type of service aimed at early disease detection. Table I indicates the participants and the scope of the various programs.[1,3-12] The range of the tests in the projects has varied from the simple combination of chest x-ray and serologic test for syphilis, to a battery of 12 tests including height and weight, hearing, vision, chest x-ray, electrocardiogram, blood pressure, serologic test for syphilis, hemoglobin, blood sugar, urine sugar, urine albumin, and self-administered brief medical history.

Multiphasic screening has been offered in California to industrial employees, the general public (in community-wide programs), university students, persons attending a county fair, and civil service employees—all, of course, on a voluntary basis. Where health education preparation could be focused on specific groups, such as employees in particular industrial plants, participation has usually ranged from 80 to 90 per cent. In one instance, it reached 99.5 per cent.

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TABLE I. MULTIPHASIC SCREENING PROJECTS IN CALIFORNIA, 1948-1954

PROJECT NUMBER	LOCATION	DATE	ADMINISTRATION	NUMBER PERSONS TESTED	DESCRIPTION OF PERSONS TESTED	TESTS EMPLOYED											
						Height and Weight	Vision	Hearing	Chest X-Ray	Electrocardiogram	Blood Pressure	Serologic Test for Syphilis	Hemoglobin	Blood Sugar	Urine Sugar	Urine Albumin	Medical History
1	San Jose	May 24 to June 4, 1948	City and State Health Departments, County Medical Society	945	Industrial workers from 4 plants				x			x		x	x	x	x
2	San Mateo	Oct., 1948, to June, 1949	County Health Department	577	Persons over 50 years of age volunteering for a nutrition study	x			x		x	x	x	x	x	x	x
3	Los Angeles	Nov., 1949, to June, 1951	City Health Department	2,250	Random sample of Los Angeles City Civil Service employees	x			x	x	x	x		x			x
4	Los Angeles	Aug. 31 to Sept. 16, 1950	University Student Health Service	3,132	Entering University students									x	x		x
5	Los Angeles	March 27 to June 30, 1950	Los Angeles County X-Ray Survey Foundation: City Health Department for limited S.T.S. program	13,597 (20,047 received chest x-rays)	Persons in downtown district responding to chest x-ray program				x			x					
6	Contra Costa County	Feb. 15 to April 14, 1951	Contra Costa Chest X-Ray Survey, Inc.	14,863 (124,118 received chest x-rays)	Persons appearing at two x-ray stations in community-wide chest x-ray program				x					x			
7	San Francisco	June 18 to Aug. 7, 1951	Prepayment Health Plan and Union Welfare Fund	3,994	Longshoremen	x	x	x	x	x	x	x	x	x	x	x	x
8	Bakersfield	Sept. 24 to 30, 1951	County Health Department and County Medical Society	2,162	Persons attending County Fair	x			x					x			
9	Contra Costa County	Nov. 28 to 29, 1951	Medical Department of corporation	209	Industrial workers in one plant	x			x		x		x	x	x	x	x

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10	Orange County	Feb. 2 to 16, 1952	County Health Department, Tuberculosis Association and Medical Society	4,167	Persons responding to community program				x									x							
11	Vernon	Feb. 19 to 21, 1952	Medical department of industry, city and state health departments	572	Industrial workers	x		x	x								x	x							
12	Los Angeles (Northeast Health District)	Feb. 25 to March 22, 1952	City Health Department, Tuberculosis and Health Association	3,203	Persons responding to community program	x			x								x	x							
13	Yolo County	March to April, 1953	County Health Department	17,000	Persons responding to community program				x									x							
14	Yolo County	Jan., 1954	Student Health Service and State Health Department	472	Veterinarians and veterinary students attending a state convention	x			x								x	x						x	
15	Imperial County	Jan. 11, 1953, to March 6, 1954	County Health Department	32,475	Persons responding to community program				x				x												
16	Los Angeles	Feb. 16 to 19, 1954	Tuberculosis and Health Association and Labor-Management Committee	862	Industrial workers in two plants	x	x		x	x	x						x	x						x	

In all cases individuals whose tests indicated some abnormality were referred to physicians of their own choice for diagnostic study and any treatment needed. Test readings went to these physicians only; they were not available to the persons screened or to any other party. In the health education accompanying each program,[13] and in the notification letters to persons screened, great pains were taken to make clear what multiphasic screening is and what it is not. For example, talks, pamphlets and other materials used in the various projects stressed that the purpose of multiphasic screening is early detection of disease; a positive test result merely suggests the presence of some abnormality, but does not constitute a diagnosis; multiphasic screening does not substitute for a visit to a physician but it often does indicate something that a physician ought to investigate; without follow-up diagnostic care, multiphasic screening accomplishes nothing; persons with symptoms of disease should consult a physician irrespective of what any test shows; and periodic health examinations by a physician are desirable.

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Costs of multiphasic screening include new, direct cash outlays and the utilization of existing services. For any particular project the "new money" cost depends upon the number and kinds of tests included, efficiency of organization, and the extent to which available community services are used. Probably the most careful estimate of total cost for any of the California projects was made in connection with the 12-test program for the San Francisco longshoremen (No. 7 in Table I). This estimate was $5.04 per person screened, of which $2.07 was in cash and $2.97 in services or materials furnished by cooperating agencies. For two projects with chest x-ray and blood sugar tests only (Nos. 6 and 10 in Table I), the total costs came to $1.50 to $1.75 per person receiving both tests. All these estimates include allowance for such indirect items as technical consultation, depreciation of equipment, health education activities, and administrative time.

By use of a wide array of services provided through 10 different community agencies the cash outlay for a recent 8-test program (No. 16 in Table I) was kept down to $0.38 per person screened.

Higher expenditures sometimes cited for multiphasic screening, $10.00 to $20.00 per person, usually include the cost of a physician's examination. This was true for one of the California projects (No. 9 in Table I). By usual definition, of course, multiphasic screening excludes examination by a physician until the time of follow-up.

One may wish also to take into account the cost of follow-up diagnostic service in addition to the screening itself. The difficulties in such an estimation are obvious. However, for one of the California projects (No. 7 in Table I) where substantially all the follow-up service was provided by one agency the cost of diagnostic care during the first four months after the program amounted to $8.98 per person responding to follow-up, or $4.09 per person tested.

The findings in multiphasic screening depend upon the type of population served, the nature of the tests used, criteria for referral, and intensity of follow-up. Because of the great variation in these factors, any summary of findings is difficult and needs to be interpreted with caution. One measure of the success

of multiphasic screening is the extent to which persons are referred to their physicians and get there. In projects which include a wide array of tests, over one-half of the participants have one or more positive screening tests and they are hence referred to their physicians. For example, in project No. 7,63 per cent received letters asking that they consult their physicians for some specific reason; almost three-fourths actually did so. In No. 16, 54 per cent were referred to their physicians because of one or more positive test results. In addition, some participants whose tests were all negative may have acted upon the general suggestion to see their physicians periodically, irrespective of test results.

Table II indicates, for each test in these projects which served more than 1,000 persons and in which substantial follow-up effort was made and records are available, the three numerical items of greatest interest in evaluation: (1) the rate of positive screening test result, (2) the rate of diagnoses confirmed, and (3) the rate of new cases discovered—all rates based upon number of participants. Positive screening test results are known quite accurately since records of these are under immediate control of agencies responsible for the administration of the program. To obtain an entry in the column "Diagnoses Confirmed" requires that the subject be notified, that he place himself in the hands of his physician, that the physician complete his examination to the point of diagnosis, and finally that the physician report this diagnosis back to some central records point. The "New Cases Discovered" column shows those cases in which the physician additionally records his judgment that the condition was not known previous to the screening test. Besides reporting some cases as "new," occasional physicians also noted that patients who had lapsed from care, for example, for diabetes or heart disease, came back under care as a result of the screening program.

Thus, the columns "Diagnoses Confirmed" and "New Cases Discovered" represent underestimates of the actual results, as well as the potential, of screening. These columns are useful indications, however, of the immediate practical results of screening so far as these are reported by the physicians to whom the suspects are referred for diagnosis.

The serologic test for syphilis appears still to be a useful screening instrument for certain segments of the population, for example, those served by projects No. 7 and 15, the former being longshoremen and the latter a migrant labor group. Difficulties in follow-up account in substantial measure for the fall in the numbers between "positive Screening Test" and "Diagnoses Confirmed."

Chest x-ray surveys have disclosed a great number of cases of tuberculosis and increasing attention is being given to their value in the detection of heart disease and lung cancer. Several detailed studies[4,12,14-18] have shown the results in California (crudely presented in Table II) and the potential of the chest x-ray as a means of finding heart disease and lung cancer. Together with the aging of the population, the rising incidence of lung cancer, and the concentration in older age groups of heart disease, cancer, and tuberculosis, these studies suggest that the chest x-ray survey may find its greatest future usefulness through

broadening the range of conditions sought, and limiting the age range of the population served to the upper age groups.

TABLE II. FINDINGS OF SELECTED MULTIPHASIC SCREENING IN CALIFORNIA, 1948-1954

NATURE OF TEST	PROJECT NUMBER	NUMBER PERSONS TESTED	POSITIVE SCREENING TEST		DIAGNOSES CONFIRMED		NEW CASES DISCOVERED	
			NO.	RATE PER 1,000	NO.	RATE PER 1,000	NO.	RATE PER 1,000
Serologic test for syphilis	7	3,974	412	104	159	40	23	6
	15	21,733	1,949	90	425	20	188	9
Chest X-ray	5	1,755,001						
(a) For tuberculosis			(a) 55,210	32	18,939	11	NA	NA*
(b) For heart disease			(b) 10,899	6	3,388	2	697	0.4
(c) For lung cancer			(c) 3,500	2	339	0.2	339	0.2
	7	3,990						
			(a) NA	NA	29	7	13	3
			(b) 21	5	9	2	3	0.8
			(c) NA	NA	1	0.3	1	0.3
	10	4,167						
			(a) 157	38	32	8	3	0.7
			(b) 40	10	NA	NA	NA	NA
			(c) 15	4	4	1	4	1
	13	17,000						
			(a) NA	NA	19	1.1	15	0.8
			(b) NA	NA	22	1.3	2	0.1
			(c) NA	NA	5	0.3	3	0.2
Blood sugar	3	2,232	26	12	16	7	NA	NA
	4	3,124	54	17	18	6	11	4
	6	14,863	259	17	127	9	73	5
	7	3,966	156	39	56	14	34	9
	8	2,162	31	14	20	10	9	4
	10	3,543	53	15	5	1	5	1
	12	2,856	87	30	27	9	16	6
	13	8,000	NA	NA	29	4	26	3
Urine sugar	4	3,132	16	5	11	4	4	1
	7	3,987	199	50	54	14	29	7
Electrocardiogram	3	2,250	395	175	110	49	NA	NA
	7	3,984	666	167	301	76	182	46
Blood pressure	3	2,250	NA	NA	228	101	NA	NA
	7	3,989	837	210	369	92	207	52
Hemoglobin	7	3,986	5	1	1	<1	1	<1
	12	2,840	233	82	30	12	NA	NA
Urine albumin	7	3,988	92	23	35	9	16	4
Vision	7	3,972	944	238	395	99	205	52
Height and Weight								
Overweight	3	2,250	301	133	301	133	NA	NA
	7	3,992	360	90	241	60	74	19
	12	2,860	1,073	375	1,073	375	NA	NA
Underweight	7	3,992	6	1	NA	NA	NA	NA
	12	2,860	90	32	90	32	NA	NA

*NA = not available

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Blood sugar screening has become well established as a technique for finding diabetes. In the projects listed in Table II the Wilkerson-Heftmann method (with Clinitron) was used for the most part. As expected, the groups with the higher rates of positive blood sugar screening test also showed a considerable degree of obesity. California experience substantiates the desirability of incorporating a blood sugar test into multiphasic screening, especially where arrangements can be made for ingestion of glucose 45 to 60 minutes prior to the test. Not only do the new cases found amply justify the small cost, but the test is easy to handle.

Collection of urine specimens, on the other hand, often presents serious practical difficulties when screening is conducted outside of some regular medical facility, e.g., in some industrial plant. In our experience, urine sugar tests, provided blood sugar screening is also done, and urine albumin tests are of dubious value.

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The 3-lead electrocardiogram is easy to administer and discloses a substantial amount of heart disease not detected by other simple tests. This justifies its use as a screening device. However, to determine its proper role in screening, further evaluation is needed both as to selection of population served and criteria for referral. Hemoglobin estimation by the copper sulfate method is readily done at the time blood is drawn for any other purpose. It is an important screening device for those groups of people among whom anemia is a common manifestation of disease, but not for other groups such as robust males.

Defects in vision and deviations from optimum weight are perhaps the easiest of all disturbances to find by simple tests. Because they seem so obvious, we may be inclined to underestimate their importance. Maintenance of maximum vision at all periods of life is a significant aspect of health, and obesity is coming into greater recognition as a factor in many chronic diseases. Several California projects have demonstrated the value of including checks of vision and weight in multiphasic screening programs, particularly as a means of encouraging persons vaguely aware of disturbances in these fields to consult a physician about them. Limited experience with hearing tests suggests the need for more careful definition of criteria for referral before routine use of audiometry in screening programs for adults.

Self-administered health questionnaires such as the Cornell Medical Index and modifications of it are helpful to the physician when he sees a patient referred from a screening program. Their value as tests themselves, that is, as criteria for referral, has not been established. Some evaluation has been done on a few simple questions proposed as indicators of heart disease.

In the development and promotion of multiphasic screening, several issues have arisen. Some of these reflect concern about real dangers; others appear to be based upon misconception. As an example of the latter, one may cite the confusion between diagnosis and screening. Even advocates of multiphasic screening unfortunately sometimes refer to the tests as "diagnostic"; *they are not.* Screening is one means of detecting disease in its incipiency; it may lead to a diagnosis, but only when the patient is examined by a physician. A positive screening test itself merely indicates a high index of suspicion for some disease condition.

One series of objections to multiphasic screening is typified by such phrases as "production-line medicine" and "mere gadgetry." There seems to be nothing inherently wrong with efficiency in health service, even the use of gadgets. These do become a danger when abused, to the detriment of the patient—whether in multiphasic screening or in a physician's individual office. Proper use of efficient methods and inexpensive devices, with appropriate attention to their limitations, appears to be entirely consistent with the best in medicine.

Another objection to multiphasic screening is the allegation that it engenders a false sense of security among the individuals whose tests are negative. Interestingly enough, the opposite hazard has also been cited, namely, that multiphasic screening may arouse too high a degree of concern about health. So far as we are aware, no actual studies of these problems have been made. To the extent that the administration of multiphasic screening raises false notions in people's minds, dangers exist. Our impression, however, has been that careful health education as a part of multiphasic screening actually seems to promote a better understanding of health and health services. In particular, our health educational efforts have emphasized that no type of testing or medical examination can provide absolute security as to health. Incorrect and dangerous notions about health may, of course, arise in connection with any health service if proper interpretation is not made.

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CONCLUSIONS

1. Multiphasic screening is the combination of several disease-detection tests performed by technicians under medical direction, applied to large groups of apparently well persons. The test results, if positive, suggest specific need for diagnosis; they do not constitute diagnosis.

2. Multiphasic screening contributes to good medical practice. It represents a practical means for the early detection of important diseases and impairments such as tuberculosis, syphilis, diabetes, certain forms of cardiovascular disease and cancer, vision and hearing defects, obesity, and anemia. Ideally, every person "ought to have" a complete health examination periodically, but obvious difficulties impede the realization of this ideal. Screening, while definitely not a substitute for health appraisal by a physician, does facilitate the discovery of disease in asymptomatic stages among persons who would not otherwise have this benefit.

3. Multiphasic screening provides an excellent opportunity for health education. During the preparation of a group to participate, information may be disseminated concerning many diseases and health practices. Taking part in such a program motivates a substantial number of individuals to seek medical attention.

4. Multiphasic screening develops and strengthens the patient-physician relationship. Many persons, who would perhaps not otherwise do so, select a personal physician as a direct result of multiphasic screening. Furthermore, many individuals, as many as one-half of all those who received the service, are referred to their own physicians for diagnostic study and any needed treatment. Each comes to his physician with a series of test results which give valuable leads not otherwise available.

5. Multiphasic screening is gaining tremendous popular support. Multiphasic screening has attracted wide attention in the public as well as the medical press throughout the country. Favorable accounts of a recent experience in Los Angeles have already appeared in the daily newspapers, labor and management magazines, the *Wall Street Journal*, *California's Health*, and other publications. Union and other consumer groups are vigorously seeking multiphasic screening as a preventive health service.

6. Multiphasic screening is inexpensive. A battery of 12 tests can be provided for about $5.00, and most of this can be in a form of contributed services from existing agencies.

7. Multiphasic screening presents an opportunity for medical leadership. Most projects involving several tests require broad community-agency cooperation. Health departments, voluntary health organizations, labor and management groups seek medical guidance in the proper development of this new type of health service. Medicine owes an important responsibility to these groups.

8. Multiphasic screening is not a panacea. It will not solve all the health problems of the people. To ensure even its appropriate contribution in the health field, technical and organizational aspects of the service should be improved. It does, however, carry us a step forward in the early detection of chronic disease.

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SCREENING FOR ASYMPTOMATIC DISEASE BY HEALTH DEPARTMENTS

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FOR many years the health of people has been the concern of conscientious and responsible government officials. The intensity of this interest has varied from time to time according to changing customs and beliefs. In the recent past, great progress has been made in clinical medicine, microbiology, epidemiology, and sanitation. In the early part of this period, attention was largely directed toward the control of infectious diseases. While it is true that these diseases have not been eliminated, they have undergone a remarkable reduction in incidence and, in the United States, are no longer among the major causes of death. The intensive work of health departments has caused many citizens to believe that government is concerned only with the control of contagious and communicable diseases. This impression is, to a degree, shared by many physicians and far too often by public health personnel. Within the last ten years many studies have been made which indicate that official health agencies must reappraise their community health programs, and direct and intensify their efforts toward control of noninfectious, especially chronic, disease.

Since the responsibility of early health departments centered around the control of infection, these units included facilities for epidemiologic investigation, immunization clinics, diagnostic laboratory services, and sanitation inspections. Gradually treatment and diagnostic facilities, bedside and field nursing services, and other basic aids came into use. Thus, gradually the scope of health work was broadened. This advance, coupled with remarkable progress in clinical medicine, served virtually to eliminate many of the infectious diseases.

In the past, state and local medical societies have approved health departments providing public health laboratory services as an aid in the diagnosis of communicable diseases. Later, laboratory testing was applied to mass segments of the population as a case-finding device, with the purpose in view of effecting early diagnosis, treatment, and cure. Thus, mass screening programs using various laboratory tests were approved by many medical societies under various

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plans. In nearly all of these plans the person examined is referred to his family doctor or to an approved medical clinic for confirmatory diagnosis and treatment if these are indicated. Such test procedures, when performed in large numbers, are economical as compared to their cost when they are done occasionally in private practice. Therefore, a central facility where these procedures can be carried out is indicated. One of the logical agencies to offer such screening services is the official health agency. Not only do health departments have the means for organizing such programs, but the precedent of referral from and to the physicians of the community has already been established. Thus approval of screening clinics, using multiple laboratory tests and procedures, by organized medical groups should not be difficult.

In addition to medical society approval and community support, a detection program using multiple screening procedures has certain other basic requirements that must be considered before it is initiated. First is an established and accepted health department with adequate personnel.[5] This is necessary since such programs can unbalance the community's health activities by consuming a large portion of the time of departmental personnel, thus diverting their attention from other responsibilities. The danger of program unbalance is more serious during the developmental stages of the program. Second, laboratory facilities must be adequate, efficient, and capable of absorbing the increased specimen load resulting from the screening clinic; otherwise, the operation of the clinic will be impaired and its relationships with physicians and the public jeopardized. Of necessity there must be adequate medical facilities for the follow-up of those screenees who show positive or doubtful results. These must include not only a sufficient number of practicing physicians within the community, but also a sufficient number of specialists to provide consultation and special diagnostic procedures. Last, the community must possess adequate treatment resources, including special clinics, hospital beds, rehabilitation and retraining services.

In addition to these essential requirements, the community should have other important resources; trained health educators to assure an adequate public and patient education program, medical social workers, public health nurses, interviewers, record analysts, etc. Such skilled personnel are necessary to assure cooperation of the patient by increasing his understanding of his condition. A well-informed patient cooperates with his physician and the clinic staff and thus obviates the need of intensive follow-up.

Screening programs should be preceded by thorough planning and careful community organization and education. It must be repeated that screening programs should be undertaken by health departments only with the cooperation and assistance of all related voluntary health agencies, and with the approval and active support of the local medical society. Their participation in the planning of the project's publicity and the educational programs assures citizen interest and participation. Frequently the mechanism of joint financial support of the screening clinic aids in developing the community's interest and, more important, serves to convince the public that such programs belong to the community.

As the physician in private practice is the one who has the responsibility for the disposition of the persons screened, it is necessary that he be thoroughly familiar with all of the aspects of the program, including not only the test procedures used, but also the clinic's system of follow-up. The records and report forms should be designed to provide the family doctor with all of the essential data he will need to interpret properly the test result and to plan appropriate clinical action. All clinic reports should be sent only to the private physician designated by the individual at the time of his screening or by whom he was originally referred. In areas where multitest screening programs have been well planned, members of the medical society served on the community planning and the medical advisory committees, and actually worked on the project with the health department staff. In these programs the quality of the medical aspects of the program was maintained, the physician-patient relationship was not only protected but was actually enhanced, and the programs were productive as a case-finding device.

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The operation of a multiple screening program has inherent valuable by-products which should be recognized and used to their fullest. The experience gained from the original five pilot clinics (Atlanta, Georgia,[2] Birmingham, Alabama,[6] Framingham, Massachusetts, Richmond, Virginia,[4] and Flanner House, Indianapolis, Indiana[3]) has demonstrated the fact that many persons who had lapsed from their physician's supervision have returned to him voluntarily as a result of the community-wide educational program. Such clinics also provide an excellent opportunity to organize a realistic health information program. This in turn permits coordination of community health education and minimizes concentration on a single disease. Health education planning emanating from such clinics serves to promote friendly and close working relationships among the various voluntary and official health agencies concerned.

In one such detection clinic operated in the City of Richmond[5] in 1950, 37,609 individuals were screened. It was found that 13,113 persons (35 per cent of the total) were suspected of one or more of the nine diseases for which they were screened. In the total group there were 16,849 suspicious findings reported. This is equivalent to 448 per 1,000 persons screened. While 65 per cent of those screened had no abnormalities noted, 27 per cent had one and 7 per cent had two. One person had five abnormalities.

In regard to specific diseases, the screening resulted in the discovery of 50 new cases of syphilis (0.6 per cent of the total number screened for this infection). There were 300 (0.8 per cent) newly discovered cases of hypertension. Unknown glaucoma was discovered in 59 persons (1 per cent of those so screened). Of 3,179 given electrocardiograms, 218 had abnormal tracings. Twenty-five of these were previously undetected cases of cardiac disease. Using 70 mm. x-rays, 37,554 persons were screened for chest abnormalities, with 1,868 individuals being re-x-rayed because of suspicious findings. This resulted in the discovery of 12 active cases of tuberculosis, 44 cases suspicious for activity, and 494 classified as inactive. In addition, there were 304 cases of positive or doubtful tuberculosis read on the 70 mm. film, which were not re-x-rayed for various reasons. The

over-all result was 943 cases discovered in 37,554 persons screened, a case discovery rate of 25 per 1,000. Urine examinations discovered 251 cases of diabetes, of which 88 (0.3 per cent) were previously unknown.

These results speak for themselves. Through the knowledge brought to light by screening, apparently normal people are made aware of danger early enough to permit prophylaxis or therapy while the disease is still in the asymptomatic phase.

These findings are not peculiar to Richmond. Results from other multiple screening tests have shown from 0.3 to 3.4 cases of active tuberculosis per 1,000 originally screened. The presence of syphilis has varied on final diagnosis from 0.8 to 43 per 1,000 persons. Heart disease has varied from a high of 100 to a low of 3 per 1,000 persons originally screened. A detailed report of these results was published by the Council of Medical Services of the American Medical Association in the publication *A Study of Multiple Screening*[9] issued in 1953. This same report also gives the characteristics of the twenty-two clinics surveyed. It was the consensus of the staff of the clinics reporting that multiscreening is useful in detection, in patient study, and that it enhances patient-physician relationships. These clinics examined 1,150,000 individuals. The percentage of persons with positive tests was uniformly high and varied with the number of test procedures offered by the clinic. From this report there is no doubt that the use of multiple screening as a part of a chronic disease detection program is warranted and that its application to other phases of public health should be more thoroughly investigated.

Other tests will be developed from time to time and will lend themselves to the screening technique. Through careful periodic re-evaluation of clinic procedures, tests may be added or eliminated as needs indicate. New tests may be added on a trial basis, to become permanent if they prove themselves of practical value. Such evaluation necessitates adequate record keeping, so that costs per test may be known and results of follow-up compared with screening procedure findings. A test must screen out as nearly perfectly as possible all those persons who actually have the disease and pass through as negative nearly all of those individuals who do not have the condition in question. The success of such an operation will depend upon the maintenance of this high degree of sensitivity and specificity for the screening tests employed.

In the wave of enthusiasm over multiple screening, many public health workers have overlooked some of the more important concepts gleaned from the evaluations of early programs. The limitations, as well as the advantages of the technique, were expressed in a previous paper.[5] One important concept, however, has not been emphasized adequately: "The technique has numerous possibilities which lend themselves to public health application. Multitesting can be performed to a great advantage in small appointment-type clinics. Multiple tests can be used successfully in the screening of limited groups of the population, such as school and college population, welfare groups, industrial groups, and the patients attending outpatient departments and other public clinics.

We believe that adequately controlled clinics on a research basis with good follow-up will give valuable data concerning incidence and prevalence of chronic diseases in industry. In many areas, industrial[1,7,8] medical services are considering the application of multiple laboratory procedures to their pre-employment examination and to their annual physical examination. . . . Several large industries and labor union medical agencies are planning to adopt the technique as mentioned above."

In a further discussion of the role of the multiple screening technique, the same paper predicted: "Perhaps when the final evaluation of mass screening studies, using multiples of ten or so laboratory test procedures, is completed, it will be found that their best application is to particular segments of the population rather than to the community at large." The Department of Public Health, City of Richmond, in cooperation with welfare and voluntary health agencies is currently planning such a program. In October, 1955, we will begin operation of a multiple screening program for recipients of public assistance. We hope that previous experiences in mass population testing and experiences of the next year with the welfare group will enable the operation of such a program at low unit cost and reasonable returns in early detection of preventable and remediable illness. A second group which we will begin screening in October is composed of municipal government employees. Similar programs for government employees have met with success elsewhere (New York State's Cardiovascular Screening Center).

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If initial trials with welfare and employee groups are encouraging, then the multiple screening unit will be offered to industry in much the same manner as are the mass x-ray and blood test screening at present. There is strong likelihood that such a program can be partially self-supporting if business, industry, and other independent groups reimburse for the service on a per unit cost basis. Several local industrial groups already have expressed keen interest in such a service.

The mass testing of entire populations suffer the same disadvantages and drawbacks as do such single screening procedures as mass x-ray. Among these disadvantages are:

1. Low case-finding rates in the general population.
2. High costs per suspect case found.
3. Unwarranted consumption of the time of key personnel of the health department and the voluntary agencies.
4. Complex and continuing community organization and effort to maintain public interest and enthusiasm.
5. Less than usual attention to the maintenance of physician-patient relationship. Almost continuous diligence is necessary to preserve this most basic characteristic of good medical practice.
6. Lack of response from groups where the illness rate is high and the case finding most productive, namely, welfare clients, the aged special industrial groups, racial groups, special areas within the city, etc.
7. Absent or inadequate facilities for thorough follow-up of all persons screened.

To be successful, a multiple screening service must be operated at low unit cost and designed to serve population groups where the highest return can be expected. The best designed program cannot return benefits to the community unless certain basic elements inherent in multitesting are incorporated in the program planning. We wish to repeat our concepts of these features:

1. The basic public health program must be broad in scope, well-staffed, firmly established, and already meeting the community's other major health needs. It must also be flexible enough to adapt to a multiple screening program without detracting from or upsetting the basic health services.
2. Community organization for health must be such that every health agency concerned gives its full and generous support, perhaps even financially, to the screening program. To secure this requires a pattern of continual cooperation among official and voluntary agencies. Further, the relationship of the medical society to the voluntary and official health agency must be firm. Such a program must have medical society approval and participation.
3. The public must be informed of the purpose and value of the service. Such information should come not only through the usual media (newspapers, radio, television, etc.) but also by direct interpretation to all organized lay groups.
4. There must be basic facilities available for complete follow-up. It is of little use to screen persons unless physicians and clinics are available and ready to follow through with diagnostic studies of those persons who are reported as suspect on screening. Further, it is useless to follow through with diagnostic service if the facilities for medical care are unavailable. The community should have available or within reasonable distance the entire range of medical facilities, well staffed by competent persons. This implies that there need be hospitals for acute illness, chronic disease hospitals, nursing homes, organized home care and particularly rehabilitation, all manned by trained professional personnel.
5. An additional need is the "teamwork" philosophy that should be uppermost in the approach used by each and every health profession. No screening will yield full value unless the professions appreciate fully each other's role and apply a total approach to patients and potential patients.

When the public health agency and its community engage in multiple screening in the manner outlined, the values and benefits can be numerous.

SUMMARY

In conclusion, we believe that laboratory screening permits the application of a proved public health technique in the prevention of chronic diseases. Further, through early discovery and prompt treatment the cost of medical care can be reduced. In turn, rehabilitation may attain its proper place in the community's health and medical care facilities, and thus more easily demonstrate its true place in restorative medicine. Last the multiple screening technique can serve as a valuable yardstick to measure the community's health problem when it is appropriately applied in selected population groups in which chronic diseases are known to be more prevalent.

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THE HOSPITAL OUTPATIENT DEPARTMENT IN THE DETECTION OF NONMANIFEST DISEASE

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INTRODUCTION

THE function of this paper, as one of a series on screening, is to consider the logic for and methods of utilization of outpatient departments as screening centers for nonmanifest disease. The reliability and yield of screening tests and their use in other situations are dealt with elsewhere.

OUTPATIENT DEPARTMENTS AS A NATURAL FOCUS FOR SCREENING PROGRAMS

There are many reasons why the outpatient services of a community hospital lend themselves properly and conveniently to screening procedures intended to facilitate detection and diagnosis of disease at an early stage. The equipment needed is in most instances already available, if not, space can be found in which to install newly procured testing apparatus. Also, the ambulatory or outpatient department of a community hospital already is serving a certain segment of the population in need of diagnostic services and is constructed, organized, and administered for provision of these kinds of services.

Many such facilities are publicly owned and operated, either under the auspices of the governing body of a nonprofit voluntary hospital, or, in the case of a tax supported hospital, by elected representatives of the public. Many other hospitals, while not publicly owned in the sense just described, serve the community well and in actual effect are community hospitals.

Conventionally, outpatient departments (a) provide complete or near complete ambulatory services to a substantial segment of the population, namely, the indigent and medically indigent, and (b) stand empty in the late afternoon and evening as well as on week ends. The practical aspects of these observations as they apply to screening revolve around two questions: first, if screening tests are valuable as a preventive technique, should not the hospital apply them at appropriate intervals to those patients who have been assigned by community policy to the hospital for care; and second, should not these facilities which are owned and/or operated in the public interest be utilized during their unscheduled hours as a community screening center?

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The reasons for affirmative answers to both questions are many, and this report proceeds on that basis. The hospital, wishing to fulfill one of its natural and emerging roles as a health center, has space, equipment, personnel, community acceptance and is usually within reasonable traveling distance of most persons who will wish to avail themselves of periodic screening. Eligibility for such screening depends on: (1) being an outpatient of the hospital, in which case screening tests can be applied in groups or singly from time to time during each year, or (2) being an apparently well individual appearing preferably by appointment at an afternoon or evening multiple screening "clinic," having either been sent by a physician or naming a physician, who, in either case, will receive the results of the tests.

The convenience and advantage of such tests to the practicing physician are well established. He is afforded certain types of advance knowledge about his patient. He receives a patient in need of diagnostic study earlier than might otherwise occur and in many cases receives new patients. Furthermore, these patients, by virtue of participation in the screening tests and by attention to properly written descriptive literature and letters, have been conditioned in many instances to want to do something constructive about their health. As such programs have developed and demonstrated their usefulness, more and more physicians have found it convenient to send to the screening center pregnant patients, dairy workers required by law to have periodic examinations, individuals requiring pre-employment examinations, and other apparently well people seen by the physician in his practice. Such screening tests are a valuable supplement to a periodic history and physical examination.

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There is, of course, nothing new about the idea of screening in outpatient departments. Serologic tests for syphilis and routine chest x-rays have been used and accepted for many years by the practicing profession and the public. In many instances, such tests have been routinely applied to outpatient populations, and the practice of using the community hospital as a mass x-ray or mass blood testing center is well known throughout the country.

We are discussing, then, an expansion in two directions of something already going on with professional and public support: the width of the spectrum of tests, and the scope of community coverage. Furthermore, rather than encouraging more capital construction and new kinds of administrative costs, the principle of making better use of what the community already owns and supports is stressed. Broader use of the community hospital outpatient department has two additional advantages: first, the hospital is the natural working focus for the physicians of the community and they are closer to and have more interest in the program; and, second, the hospital and various other health agencies with an active or potential interest in screening very likely already have coöperating relationships in other types of service which were established in the best interests of each doing a better job for the community through integration of their programs. The importance of such cooperation will be referred to through specific examples.

SCREENING PROCEDURES IN THE OUTPATIENT DEPARTMENT

It is not the purpose of this report to recommend a standard pattern for screening but rather to emphasize the flexibility with which the entire concept can be approached. Some outpatient departments which are fairly large can be easily adapted to provide a smooth flow of traffic through a screening line-up. Others require more careful study in assignment of space for screening procedures, in order to make as many tests as possible without interrupting other normal services given in the department or in the adjunct diagnostic services, such as x-ray, laboratory, and electrocardiography. Most community hospitals today can be adapted to a multiple screening program.

With respect to reactions of the screenee to his surroundings it can be said that patients who are being screened as a part of an outpatient visit view the procedures as part of their regular "work-up." Individuals coming to mass screening clinics on a voluntary basis are there by choice, and are quite willing to cooperate with appropriate guidance from testing point to testing point. The human factors most important in operation of a screening clinic are: understanding on the part of the individual being screened, the efficiency and spirit demonstrated by the personnel, and the feeling that the hospital and cooperating agencies are interested in the individual's well being.

These screening tests which are most frequently applied in multiple screening include the following:

1. X-ray of the chest. This may be a 70 mm. film, a standard chest film, or an intermediate size. The selection will depend more on local circumstances than on the advantage of one over the other.
2. Lead I electrocardiogram or some other limited scope electrocardiogram.
3. Measurement of height and weight.
4. Measurement of blood pressure.
5. Collection of a blood specimen which is divided into three portions.
   a. For determination of the blood sugar level in the "Clinitron" and its estimation as to whether it lies above or below 130 mg. or some other defined level.
   b. Hemoglobin estimation, usually made first by copper sulfate technique, followed by a second determination by another method, frequently the Haden-Hausser, if it is estimated that hemoglobin is below the lower limit of a normal range for either the male or the female.
   c. Serologic test for syphilis performed either in the hospital laboratory or by one of the health department laboratories.
6. A urine specimen which is tested for the presence of albumin and sugar.

In addition to these customarily applied tests, many screening clinics also test for visual acuity and for impairment of hearing. The vision test is applied usually with one of the sight testing machines such as the Sight Screener or Orthorater or with the Snellen chart. The hearing level determinations are performed conveniently with the outpatient department audiometer.

Beyond these tests many other screening procedures are under evaluation in this country: application of the tonometer by skilled technicians to detect the presence of glaucoma; Papanicolaou smears taken from the cervix and vagina and, in at least one experimental study, from urinary sediment. Examinations

of the teeth have been and in some instances in this country are routinely made. A well-organized screening program offers many opportunities for experimental work with added tests with very little added cost and difficulty.

The application of these tests to the two groups under discussion in this paper, namely the outpatient population of the community hospital and groups of well people recruited from the community, conventionally is handled by two different sets of personnel. The individual registering in the outpatient department clinic can be registered also for multiple screening on a record which should become a part of his outpatient and preferably unit record in the hospital. Such a person routinely coming to the outpatient department may, but need not, have all screening tests applied at a single time. In the latter method the outpatient department can designate one of several people to see to it that over a period of months the entire spectrum of screening tests is accomplished on different visits. The admitting clerk, the outpatient department supervisor, the clinic clerk or a well-trained volunteer can each easily handle such records and see to it that within the specified time limits established by the local policies governing the program the individual is screened and rescreened as the years go by. The tests are performed by nurses or technicians who may have other duties or, if the project is large enough, may be present only for screening. The chief argument for screening outpatient populations, of course, is that since they are an underprivileged group and in need of diagnosis and care the probability of a higher yield of positive screening tests exists. The same argument applies to the patient population privileged to have private physicians. A community screening center where he can send his patients is logical and helpful since the practicing physician rarely has time or facilities for complete screening.

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Groups of well individuals coming to the outpatient department of the community hospital for screening can be handled in the late afternoon, evenings, and week ends by a staff of both paid and volunteer personnel. In the screening program at the Hunterdon Medical Center, organized and administered until recently by the author and described here for illustrative purposes, the recruitment of individuals for group screening was handled by a paid member of the organization's public information department. This same work could be handled just as well by an executive secretary or a committee of a voluntary health agency, by the health educator of a health department, or by other individuals with similar community interests or obligations. It is preferable that individuals coming to the screening clinic do so by appointment. This prevents undermanning and overloading and makes for much better public relations.

As the individual coming to a group screening session enters the outpatient department (diagnostic center) he is greeted by an attractively uniformed volunteer, one of forty-five volunteers who have learned to work in the multiple screening line-up and who have learned every volunteer job at every post so that there can be rotation and substitution of personnel with a minimum of difficulty. The individual is handed a card with a number which he holds until his turn comes to proceed through the screening.

He is then called to proceed in succession through the following posts in the screening line-up:

1. Registration. This is handled by a volunteer. The individual is asked to fill in a very simple statement regarding past history of certain diseases in his family, known existence of diseases in himself which might be detected by screening and whether or not these are under medical attention. He provides a minimum of identification data and names a personal physician to whom the results of the screening tests are to be sent. This is a mandatory prerequisite to screening in this type of program.
2. He then is sent to a second registration point in the x-ray department where his name and screening number are entered in the x-ray logbook, also by a volunteer. He is guided to the x-ray unit where a paid technician takes the film. This technician may be one of several individuals, either from the regular x-ray technician staff or from other hospital personnel who have learned from the x-ray staff how to perform this simple procedure. There has been no difficulty in recruiting individuals among hospital personnel who want to work overtime to add to their income.
3. The individual is guided by the volunteer at the x-ray department to the electrocardiographic room where a volunteer applies the necessary electrodes and a paid technician takes the reading. Again the technicians are either those who have full-time technical responsibility in this department or who have learned to take Lead I electrocardiograms with the direct writing instrument.
4. The individual is directed next to a room where a volunteer measures his blood pressure. He then proceeds to an adjacent room where a technician, medical student, or nurse again measures his blood pressure and draws a blood specimen. The test for hemoglobin detection by the copper sulfate method is performed at once with drops of blood falling directly from the syringe. The rest of the specimen is divided between tubes for glucose determination and serologic tests for syphilis. A volunteer assists the individual who is drawing the blood, handing him the needle and syringe, rinsing the equipment when it has been used, holding the tubes, agitating the tube containing chemical to prevent clotting, wrapping the tube to be mailed to the state health department for serologic test for syphilis, identifying all tubes properly with numbers and carrying on a friendly conversation with the individuals being tested to keep them at ease.
5. The registrant proceeds to the clinic weight scales where height and weight are measured by a volunteer, then guided to one of two rooms, depending on the sex of the individual. A volunteer instructs the man or woman on how to leave a proper urine specimen. Having the individual leave a fresh specimen at the time of the visit is superior to having a specimen mailed in in a container containing a chemical preservative. However, the latter method is commonly employed. The specimen as collected by the procedure here described is immediately delivered by the volunteer to the clinic laboratory. Here a technician is examining the previously drawn blood specimen. He operates the "Clinitron," repeating each positive test once to be sure it has not resulted from a technical error. In the event the "Clinitron" test indicates a blood sugar above 130 mg., the true glucose level is determined by one of the various chemical methods in use in the laboratory; the Smogyi-Nelson procedure is frequently employed. He determines the hemoglobin by another method in addition to the copper sulfate method if the first test indicated the possibility of a below normal value. He performs the albumin and sugar tests on the urine

specimens. Finally, he is responsible for closing out the clinic operation each evening, returning equipment and specimens to the laboratory.

There is nothing fixed about the arrangement of these various posts. Hearing and vision tests or other procedures may be interposed at any point in rooms properly equipped.

In the foregoing plan, it is seen that extensive use of volunteers is made to reduce costs and to make use of those people in the community who wish to render a public service. The drop-out rate of this particular group of volunteers has been the lowest of any group in the experience of the author. Other screening programs utilize paid personnel throughout, either directly recruited from among the hospital staff or assigned by various health agencies in the community. The number of people who can be screened is directly related to the efficiency of the clinic, the number of tests performed in the screening line, and the number of hours in which the program is in operation in a given year. The particular program under description operates in a small medical center in a rural community. It functions nine months a year, four nights a week, and screens each night from thirty to thirty-five individuals who wish to be screened. Recruitment of groups who wish to be screened is easily carried on through industries, churches, service clubs, and other community organizations, requiring therefore less clerical and secretarial help from the program staff itself. In fact, the appointment roster is usually filled several weeks in advance.

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Results of the screening tests in the community evening clinics are mailed to the personal physician named by the individual. Follow-up on these tests is the responsibility of the physician. The best developed program, however, is one which has a close interlocking relationship with the local health department for purposes of follow-up on people who have findings which are significant but who fail to proceed to their physician's office to determine the outcome of the tests. Discussion between the hospital personnel, health department personnel, and representative members of the local medical profession will determine priorities and to what extent each individual is to be followed up and by what methods. The simplest and most direct method is a follow-up letter. This is conventionally followed by a telephone call and finally by a visit from a public health nurse, if the situation is serious enough to warrant this much time and effort. Such arrangements must be determined in the light of local circumstances and there is no one pattern that fits all communities.

ADMINISTRATIVE AND FINANCIAL ASPECTS OF SCREENING PROGRAMS

The assignment of the administrative responsibility for a screening program in an outpatient department will depend on the local situation. It may be made the responsibility of the outpatient department supervisor; an individual may be assigned by the health department; a screening program is the logical concern of departments of internal medicine in larger departmentalized hospitals; it may be under the administrative supervision of the laboratory service or the x-ray service. It is the kind of program which can be administered by

one individual and a secretary, with proper support and understanding from other departments in the hospital.

The multiple screening program offers an ideal opportunity in a community for various agencies interested in health to cooperate. Multiple screening is a logical concern of health departments, heart associations, cancer societies, tuberculosis association chapters, and any local citizen group interested in promoting adult health. The methods of working tegether are varied. Basically, however, they involve the following:

a. *The Loan or Gift of Equipment.*—For example, the program with which the author has had the most experience has utilized sight testing equipment loaned by the Public Health Service through the State Health Department; a direct writing electrocardiograph and a 70 mm. chest x-ray photofluorographic unit, each donated by the state health department; a "Clinitron" blood sugar testing unit on loan from the United States Public Health Service through the state health department. The health department also performs the serologic tests for syphilis.

b. *Allocation of Funds.*—This can be in a lump sum toward partial support of a service. For example, the heart association may pay toward the salary of a technician who operates in a screening clinic. Funds may also be made available on a contract basis with the state health department for the hours of technical service performed. The tuberculosis association can make lump sum contributions toward the cost of chest x-rays or may pay so much per x-ray. Certain state health departments have a program of incentive to hospitals to take chest x-rays by paying for each one properly reported.

c. *Records Development.*—Through local, state, or Federal offices of health departments or voluntary agencies, local hospitals can get a great deal of assistance in the proper design and processing of records.

d. *Assignment of Personnel.*—Agencies with staff personnel may wish to participate in screening programs by actually assigning technicians, public health nurses, clerical assistants, and others to work in the screening program.

The sources of funds to local community hospitals for multiple screening are basically three in nature, of which two have already been mentioned. These are (a) grant-in-aid contracts with health departments or other health agencies; (b) lump sum contributions from health organizations such as the heart association, cancer society, tuberculosis association, etc., and, in addition, (c) direct charges to individuals who are being screened. There is a sizeable segment of the community population who are interested in being screened and who are willing to pay for it. A recent questionnaire study of a 10 per cent sample of all individuals screened in the program under the author's administration* showed an overwhelmingly favorable response from the public and a willingness to pay toward the cost of the screening program.

*Direct operation of the program during its latter months has been the responsibility of a member of the Department of Internal Medicine, Dr. Pauline Goger.

In the future an additional source of funds to hospital for multiple screening could appropriately come through voluntary health insurance plans. There are indications of activity on the part of insurance groups which may lead to supplemental provision for preventive services.

The hospital administrator should remember also that a screening program which uncovers suspicious findings to be further evaluated by a physician inevitably results in a certain proportion of people being returned to the hospital for more definitive tests of varied nature, for which the individual is expected to pay the going rate. Thus, while primarily intended as a preventive service for the good of the community, a screening program leads to a broader utilization of an existing community service and increased return to the hospital from expanded use of laboratory, x-ray, and electrocardiographic facilities.

The overhead problem created by a screening program such as has been mentioned is negligible. The outpatient department has to be cleaned daily, heated and maintained around the clock and throughout the year. Utilization of this space a few more hours a week for the good of the community adds very little to the overhead other than the additional electricity required for lighting and operation of equipment. Also one may logically ask the question as to whether a community-owned facility which has been bought and paid for by contributions from the public and which is giving a service to the public can be properly considered to have an "overhead and depreciation."

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The hospital administrator should be aware also of the great value to the hospital of multiple screening of all hospital personnel and volunteers annually. This is a tangible health service which employees appreciate, for which they can be easily scheduled, and which they should receive annually and in some instances every six months because of the increased hazard of their work (for example, exposure to tuberculosis).

Finally, the public relations value of a multiple screening program cannot be overlooked. Entire communities have been known to change their attitude toward a community hospital when a properly organized screening program was made available to all members of the community who wished to avail themselves of it. The interest of the medical profession, the hospital, and the health agencies in the health of presumably well persons is of inestimable value in cementing the positive relationships which should exist between every community hospital and its public. There is real value in having people visit their hospital as part of an interested and friendly group under pleasant circumstances. It may be speculated (and the question should be studied) that a well-run screening program, which lessens the individual's fear of the hospital and of diagnostic tests, may shorten the interval between the subsequent onset of symptoms and the time when he first seeks medical advice. If this were proved, it would be of significance to all concerned with preventive medicine, since delay in diagnosis is one of the major problems which still faces all health professions today. The first and often the most significant delay is that occasioned by the patient himself in his tardiness in reporting for investigation. Anything which breaks down this resistance and fear is in the public interest.

SUMMARY

The purpose of this paper has been to deal with some of the general considerations of a screening program as a part of the routine service given in an outpatient department of a general hospital, both to patients routinely seen there and to community recruited groups of well people. The many reasons which justify and should encourage such utilization of the outpatient department, the flexibility with which such a program can be approached, the many sources of community interest and support, and the advantages to the hospital, the medical profession, and the public, have all been described.

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SCREENING IN A GROUP PRACTICE PREPAID MEDICAL CARE PLAN

As Applied to Periodic Health Examinations

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BASED upon favorable previous experience with multiphasic screening surveys in this area,[1,2] multiple screening techniques have been applied to periodic health examinations offered to members of the Kaiser Foundation Health Plan since 1951. This review is an evaluation of 1,000 patients so examined in 1952.

As the prime objective of multiple screening is not merely to detect unrecognized disease, but to obtain prompt referral of the patient to the doctor for early care,[3] the coordinated facilities of a hospital are eminently suited to implement an elaborate screening program, particularly if the screening is done on a continuing basis at periodic intervals.[4]

The advantages of multiphasic screening include (1) improved service to the patient through close integration of several test procedures, (2) possible earlier detection of unsuspected disease among apparently healthy people, (3) motivation of people to become health conscious, (4) motivation of physicians to practice health supervision and preventive medicine, and (5) economies in personnel time and administrative expense.[5]

Several criticisms have been directed against multiphasic screening. Criticism is justified where there is a lack of participation and supervision by the physicians who ultimately become responsible for the care of the patient. It is unsatisfactory when the practicing physicians are unable to ensure the maintenance of satisfactory standards of technical quality of the tests, and the continuity of follow-up between screening and treatment. In this program, complete integration of the screening tests and the subsequent medical care eliminated these problems. Again, criticism has been directed against the use of screening tests as a "cheap" substitute for complete diagnostic procedures, and this is a valid criticism to the extent to which it may be true. Although a specific gravity test by the copper sulfate method may accurately determine whether the hemoglobin is over or under 13 Gm., it should never be used to replace a quantitative measurement for hemoglobin. Likewise, a strip of Lead I electrocardiogram, when abnormal, is useful as an index of possible cardiac

disease, but should never be used to replace the standard complete electrocardiogram as a diagnostic tool. Thus, each screening test must be used for the limited detecting purpose for which it was designed, and not as a substitute for more complete diagnostic procedures. In this program, patients with abnormal screening tests were usually referred for confirmatory and supplementary complete diagnostic evaluation.

This multiphasic screening program, supervised and conducted by the physicians who furnished the medical review, physical examinations, treatment, supplementary consultations, and follow-up care, all integrated and essentially prepaid through a comprehensive medical care plan, and associated with an educational program advising patients of the desirability of periodic health examinations, has resulted in an effective and economical program of preventive medicine.

PROCEDURE

General Screening.—Patients first received the following multiphasic screening procedures during a 60-minute appointment period: completion of a health questionnaire, measurement of height, weight, and blood pressure, tests for urine albumin, blood hemoglobin, blood or urine sugar as collected one hour after ingestion of 100 Gm. of glucose, a serologic test for syphilis, chest x-ray, and a Lead I electrocardiogram.

Testing Methods.—

Health questionnaire in the form of a modified Cornell Medical Index-Health Questionnaire,[6] comprising 95 significant medical questions, was self-administered by the patient.

Urine albumin was tested for by the sulfosalicylic method[7] using 4 c.c. urine and 3 drops of 20 per cent sulfosalicylic acid.

Blood hemoglobin was determined by the specific gravity of whole blood in copper sulfate solution.[8]

Blood glucose was screened by the Wilkerson-Heftmann method one hour after ingesting 100 Gm. of glucose[9] and, when quantitatively determined, was measured by the method of Folin-Wu.

Urine glucose, when performed, was qualitatively screened by Clinitest tablets.[10]

Serologic testing for syphilis was by the V.D.R.L. test.

Chest x-ray was carried out through use of the 70 mm. photoroentgen unit.

Lead I electrocardiogram was performed by the patient holding two moistened arm leads.[11]

Special Procedures.—Women over 35 years of age were referred for examination of the breasts and pelvic organs and a cytologic examination[12] of a smear of the cervix. Men and women over 40 years of age were referred for sigmoidoscopy examination.

Doctor's Visit.—Patients were then requested to return one week later for an appointment with an internist, who reviewed the health questionnaire, obtained any pertinent additional history, performed a physical examination,

appraised the laboratory screening tests, and then reviewed with the patient his health status.

Follow-up Visits.—Any necessary follow-up visits or additional consultations were then arranged by the physician.

DESCRIPTION OF STUDY SAMPLE

A random sample of 1,000 cases was selected from a total of 9,403 patients examined by the multiphasic screening technique, during 1952, at the Kaiser Foundation Hospital in Oakland. Sixty per cent of the patients were women. The majority of all patients examined were between 25 and 55 years of age. The average age of the men examined was 43 and of the women 39 years.

The patients' occupations were coded according to a revision of the "Classified Index of Occupations and Industries," prepared by the Bureau of the Census. Of the male patients examined, 31 per cent were craftsmen, operators, and kindred workers; 20 per cent professional and technical workers; 12 per cent managers, officials, and proprietors; 9 per cent clerical workers; 8 per cent unskilled laborers; 6 per cent service workers; and the remaining were in miscellaneous occupations. Among the female patients examined, 52 per cent were housewives; 20 per cent clerical workers; 10 per cent professional and technical workers; 5 per cent service workers (excluding housewives); and the remaining were in miscellaneous occupations.

ANALYSIS OF HEALTH QUESTIONNAIRE

A questionnaire, comprising ninety-five questions, modified from the Cornell Medical Index-Health Questionnaire,[6] was completed by each patient. Each item in this questionnaire covered a significant symptom or history of illness. In our experience, this modified questionnaire was satisfactory and took half as long to complete as the Cornell Medical Index.

For the ninety-five questions asked, about 20 per cent of the women and 10 per cent of the men answered "yes" to twenty or more questions; 68 per cent of the women and 72 per cent of the men answered "yes" to a total of from five to twenty questions; and about 12 per cent of the women and 18 per cent of the men answered "yes" to fewer than five questions.

The questionnaire was most useful to the clinician in quickly appraising the need to direct further investigation as to the possible presence of psychosomatic disorders. Questions most frequently answered by both sexes in the affirmative were: "Do you attempt to push or drive yourself?" answered in the positive by 41 per cent of all patients; "Do you often get spells of complete exhaustion or fatigue?" answered "yes" by 36 per cent of all patients; and "Are you often bothered by thumping or racing of the heart?" answered "yes" by 28 per cent of all patients.

In other diagnostic categories, the pattern of answering the health questionnaire varied considerably between the men and women.

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ANALYSIS OF LABORATORY SCREENING TESTS

The laboratory screening tests were performed according to the methods outlined previously. In 61.3 per cent of the 1,000 cases, all screening tests were completely negative; 30.2 per cent of the patients had one abnormal (or doubtful) test result; 7.3 per cent had two abnormal (or doubtful) test results; 1.0 per cent had three abnormal (or doubtful) test results; and 0.2 per cent had four abnormal (or doubtful) test results.

For all patients receiving these screening tests, 37.1 per cent had one or more supplemental laboratory examinations. This percentage was the same for each sex. Of the 613 patients with completely negative screening tests, 133 (21.5 per cent) had supplementary tests ordered for various reasons by the examining physicians. Of the 387 patients with one or more abnormalities in the screening tests, 238 (61.5 per cent) had supplementary tests.

Supplementary tests were ordered when the screening tests were abnormal, except in instances where the patient was already known to the clinician and it was not felt that supplementary tests were necessary. This was not an infrequent occurrence, since many patients had been regularly visiting the physicians for several years.

TABLE I. RESULTS OF CERTAIN LABORATORY SCREENING TESTS

LABORATORY SCREENING TEST	SCREENING RESULTS (NUMBER OF PATIENTS)	
Hemoglobin	Positive	86
	Doubtful	10
	Negative	913
Blood glucose	Positive	20
	Doubtful	—
	Negative	980
Urine glucose	Positive	101
	Doubtful	—
	Negative	899
Urine albumin	Positive	4
	Doubtful	34
	Negative	962
VDRL test for syphilis	Positive	9
	Doubtful	21
	Negative	970
EKG Lead I	Positive	155
	Doubtful	12
	Negative	833
X-ray (lungs)	Positive	21
	Doubtful	75
	Negative	904
X-ray (heart)	Positive	14
	Doubtful	26
	Negative	960

Table I indicates the results of the laboratory tests. A hemoglobin below 13 Gm. by the screening test was found in 86 patients. For 39 of these 86 patients a supplementary hemoglobin determination was performed by the Klett colorimetric procedure. Among these retested patients 39 per cent measured below 13 Gm. by the confirmatory test.

Of 20 patients who were found to have blood glucose values over 180 mg., one hour following ingestion of 100 Gm. of glucose, 15 were subsequently retested by standard blood quantitative determination. Only 2 patients were confirmed to have diabetes mellitus.

Of a thousand consecutive patients* tested also for urine sugars, one hour following ingestion of 100 Gm. of glucose, 101 were found to have positive tests for glucose in the urine by the Clinitest method,[10] and each of these 101 patients immediately had blood drawn for a quantitative blood glucose determination. Of these 101 patients, 60 had blood sugars over 180 mg. per 100 c.c., 6 had blood sugars between 170 to 180 mg., and 35 had blood sugar values below 170 mg.[13] The urine sugar test appeared to be a more reliable screening test for diabetes in this series in that it "discovered" a higher per cent of diabetic patients and had fewer false-positive tests.

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For 38 patients, urine albumin tests were found to be positive (3 or 4 plus reactions) or doubtful (1 or 2 plus). Twenty-five of these patients were retested and 3 were found to be positive or doubtful.

Among the 1,000 persons screened for syphilis, 30 had positive or doubtful tests. Of these, 17 were retested. Of the 4 persons with positive screening tests retested, 2 were positive; of the 13 doubtful screening tests, none was positive and 3 were again doubtful.

There were 167 patients who had positive or doubtful Lead I screening electrocardiograms. Of the retested patients, who had supplementary full 12-lead electrocardiograms, 81 per cent were abnormal.

It is noteworthy that with reference to the screening electrocardiograms and x-rays, the practicing physicians received the actual cardiogram and 70 mm. minifilm attached to the patient's chart. As a result, many doubtful reports by the electrocardiographer and the radiologist were not retested when physical examination revealed obvious reasons for questionable screening reports.

Twenty-one patients had abnormal screening 70 mm. chest roentgenograms and, in an additional 75 cases, the screening results were doubtful. Among the doubtful cases, 14 per cent of these re-examined by standard 14 by 17 inch chest x-rays of the lungs were abnormal, 54 per cent were again doubtful, and 31 per cent were negative.

Of the abnormalities reported for the heart by 70 mm. screening chest x-ray, 55 per cent of the retested x-rays were abnormal.

ANALYSIS OF CANCER DETECTION SCREENING

Of the 381 women in the 35-year or older age group, 292 (76.6 per cent) were examined in the cancer detection clinic, a subdivision of the department

*These data pertain to an additional series of patients—not to the random sample of 1,000 cases referred to earlier in the paper.

of gynecology, where pelvic, rectal, and breast examinations, and a cytologic examination of a smear of the cervix were performed.

Of the 292 women examined, 112 were reported to have pelvic abnormalities. The most frequent abnormalities found were cervical erosion, slight cystocele and/or rectocele, and slight uterine displacement. Six patients were reported to have suspicous findings for cancer on pelvic examination; 4 of these cases were ultimately diagnosed as chronic cervicitis, 1 as atrophic menopausal vaginitis, and 1 was discovered to have a pelvic tumor which proved to be an adenocarcinoma of the Fallopian tube.

Thirteen patients were found to have breast abnormalities, only 2 of whom were considered in sufficiently serious condition to require referral to a surgeon. One of these lesions was diagnosed as mazoplasia, and the other as probable cystic mastitis. Except for 16 cases of hemorrhoids and minor anal conditions, no important rectal abnormalities were discovered in this group of women.

Of the 292 women who received a cytologic examination of a cervical smear, 6 were reported as "not entirely negative" for suspicious cells for cancer. However, follow-up studies showed 5 to be normal and 1 woman to have an endocervical polyp.

ANALYSIS OF SIGMOIDOSCOPY EXAMINATION

During the year 1953, sigmoidoscopy examinations were added to the multiphasic screening program as a routine procedure for all patients over 40 years of age. Of 1,000 patients in whom sigmoidoscopy was performed, 58.5 per cent were males and 41.5 per cent were females. Of the 1,000 patients, 5.8 per cent were found to have rectal or sigmoid polyps and 1 patient was found to have a carcinoma of the rectum.[14] Rectal or sigmoid polyps were discovered in 7.5 per cent of the males examined, and in 3 per cent of the females. In every instance, this abnormality was previously unknown to the patient.

TABLE II. ABNORMALITIES NOTED AT PHYSICAL EXAMINATION IN 1,000 PATIENTS STUDIED

EXAMINATION	TOTAL ABNORMALITIES		ABNORMALITIES IN MALE PATIENTS		ABNORMALITIES IN FEMALE PATIENTS	
	NUMBER	PER CENT	NUMBER	PER CENT OF MALES	NUMBER	PER CENT OF FEMALES
Ear, nose, and throat	120	12.0	59	14.9	61	10.1
Neck or thyroid	49	4.9	11	2.8	38	6.3
Heart	111	11.1	36	9.1	75	12.4
Lungs	33	3.3	24	6.1	9	1.5
Abdomen	125	12.5	48	12.2	77	12.8
Extremities	145	14.5	61	15.4	84	13.9
Rectum	59	5.9	41	10.4	18	3.0
Genitalia	71	7.1	43	10.9	28*	4.6*
Miscellaneous	160	16.0	51	12.9	109	18.1

*These figures do not include abnormalities found in the special cancer detection examination for women.

ANALYSIS OF PHYSICAL EXAMINATION

Of the 1,000 patients who took the multiphasic screening test, 97.6 per cent returned 7 to 10 days later for a general physical examination by an internist. Table II presents the frequency of abnormalities found on physical examination, divided into broad categories. Of the 395 males in this study, 55.9 per cent had one or more abnormalities and 42.3 per cent had no abnormality on physical examination. Of the 605 females, 52.9 per cent had one or more abnormalities (not including those found in the cancer detection clinic), 44.3 per cent had no abnormality reported, and 2.8 per cent did not return for the physical examination.

TABLE III. DISEASES DIAGNOSED, NUMBER OF CASES PER 1,000 PATIENTS

DISEASE	NUMBER OF CASES
All Diseases	1,391
Pulmonary tuberculosis, inactive	35
Syphilis and its sequelae	9
Other infective and parasitic diseases	13
Malignant neoplasms	9
Benign neoplasms	54
Allergic disorders	39
Diseases of the thyroid	27
Diabetes mellitus	7
Obesity	189
Other endocrine and nutritional disorders	52
Blood disorders	47
Anxiety state	58
Psychoneurotic disorders, other, mixed and unspecified type	98
Other psychoneurotic and personality disorders	31
Neurologic disorders	18
Eye diseases	18
Ear diseases	19
Rheumatic heart disease	6
Arteriosclerotic heart disease, including coronary disease	14
Functional disease of heart	10
Hypertensive disease	88
Varicose veins of lower extremities	19
Hemorrhoids	18
Other circulatory diseases	14
Acute respiratory infections	15
Other diseases of respiratory tract	50
Duodenal ulcer	20
Hernia of abdominal cavity, mainly inguinal	15
Functional disorders of intestines (mainly constipation and irritable colon)	37
Other diseases of digestive system	27
Urinary system diseases	10
Diseases of male genital organs	13
Infective diseases of uterus, vagina and vulva (mainly cervicitis)	48
Disorders of menstruation	21
Other female genital diseases	63
Complications arising from pregnancy	3
Skin diseases	45
Osteoarthritis and allied conditions	24
Other arthritis and rheumatism (except rheumatic fever)	23
Other diseases of bones, joints and musculoskeletal system	28
Congenital malformations	5
Symptoms of senility and ill-defined conditions	72
Accidents and injuries	6
Pregnancy	11

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The most common abnormality recorded for the abdomen was obesity; for the extremities, varicose veins; and for the rectum, hemorrhoids.

A systolic blood pressure of 160 mm. Hg or over was found in 9.9 per cent of the patients. A diastolic blood pressure of 95 mm. and over was found in 8.2 per cent.

ANALYSIS OF FINAL DIAGNOSES

Table III shows the illnesses finally diagnosed as a result of the composite of the various examinations.

Selecting a few specific diagnoses, it was found that of 20 patients diagnosed as having duodenal ulcer, only 4 had indicated on the questionnaire that this condition was previously known to the patient. Of 64 patients with hypertension (without heart disease), only 33 were previously aware of it. Of 15 males with hernia of the abdominal cavity, only 5 had indicated on the questionnaire that they were previously aware of this condition.

In 22.3 per cent of the patients no diagnoses of abnormality were made. In 36.2 per cent, 1 abnormality was discovered; and in 25 per cent, 2 diagnoses were made.

SUMMARY AND CONCLUSIONS

A multiphasic screening program, supervised and conducted by the practicing physicians who furnished the medical review, physical examination, treatment, supplementary consultations, and follow-up care, all integrated and prepaid through a comprehensive medical care plan and associated with an educational program advising patients of the desirability of periodic health examination, has resulted in an effective and economical program of preventive medicine.

In this series 97.6 per cent of all patients who took the multiphasic screening tests returned to their physicians 7 to 10 days later for a general physical examination. Of this latter group, 62.4 per cent were referred for supplementary consultations and treatment. In only 22.3 per cent of all patients were there no diagnoses of abnormality made.

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SCREENING FOR DEFECTS AMONG SCHOOL CHILDREN

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OF ALL institutions the schools were probably the first to employ screening techniques routinely as a method of preventing disease and discovering incipient disability.

In a delightful little book, Dr. William F. Barry[1] of Woonsocket, Rhode Island, has this to say of medical inspection in 1903: "Among the diseases known commonly as 'school diseases' some have been discussed as being contagious, others as noncontagious; but all are to a greater or less extent preventable, either by discovery and isolation or by better application of hygienic detail. Within the last decade, in the larger cities of this country and Europe, the plan has been adopted of having a regularly appointed medical officer, whose duties are a daily examination of all suspected illness, whether contagious or not; a regular examination of each child's sight, hearing, and seating; and an investigation as to proper heating and ventilating. At first some objections were raised to the adoption of such a practice. The expense was deplored, but in most instances the fees of the inspector were fixed at a merely nominal sum of one or two hundred dollars a year." Barry goes on to say that in Boston in 1900, some 15,573 school children were examined by medical inspectors, yielding a rich harvest of 505 specific infectious diseases; 2,609 oral and respiratory diseases; 37 diseases of the ear; 431 diseases of the eye; 3,421 diseases of the skin; and 3,568 miscellaneous diseases. Only 4,952 children were found to be free from disease.

As long ago as 1913, specific schedules[2] for classroom teacher observation of the health of school children had been worked out and teachers were being urged to make systematic health surveys and to keep notes for the physician.

Vision and hearing testing and the measurement of height and weight have been a part of regular supervisory health services from the start.

For decades the annual physical examination of every child together with hearing and vision tests have been required by law in many States. During most of the first half of this century, countless hours, huge sums of money, and the devoted effort of physicians, nurses, and teachers have been poured into the process of "detecting defects." Yet all this preoccupation with detection

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yielded much disappointment and frustration when one considered what was done about "correcting the defects."

An early World War II study by Ciocco, Klein, and Palmer[3] tabulated hundreds of defects which had been noted and carefully recorded in the school health records year after year but were nevertheless still present for rediscovery by physicians examining young men for Selective Service.

Following the recent war, dissatisfaction with school health programs was so widespread and intense that many traditional practices came in for some sharp reappraisal. A number of detailed studies were done "not only of the kind, volume and distribution of health practices but of the relative merits of these practices in terms of end results." One of the most important of these was the Astoria Demonstration Study.[4] Well planned and convincingly reported, this project brought in to sharp focus increasing criticism of mass physical examinations, hurriedly performed by physicians on hundreds of children fully or partially clothed in a noisy place without privacy and without the parent present. Certainly this was a travesty of good medical practice. Even more important, if a prime objective of such an examination is to educate the parent and child to understand the significance of a health problem and to take responsible action on that knowledge, then this was indeed the antithesis of health education and could only lead to disrespect for the procedure on the part of both parent and child.

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In a controlled study now underway in Rochester, New York, Yankauer and Lawrence are endeavoring to answer the question of whether "the avowed purposes of periodic medical examinations of school children are realistic or merely rationalizations advanced to justify anachronistic procedure." In a preliminary report,[5] findings are announced from careful pediatric health appraisal of a selected 15 per cent sample of all first-grade school children. This sample of 1,056 children representing all levels of socioeconomic status was evaluated by the same pediatrician. The examination consisted of a complete and careful medical history and a physical examination of all systems. These procedures required an average of 30 to 40 minutes per parent and child. In cases of doubt, referral for further study was made. All but 59 of these first-grade children had received prior school entrance examinations as part of the regular school health program. For these prior examinations the ratio of those performed by family physician to those performed by school physician was 1.4, varying from 3.2 in the high socioeconomic group to 0.68 in the low. From the group of 997 children having a prior examination, only 21 children were found to have adverse conditions that were neither known nor under care. Further analysis of these disclosed that only one child, an epileptic with nocturnal seizures, could be said to have a serious condition requiring prompt medical attention that was neither present at the time of the "school entrance" examination nor could have been discovered through teacher referral. Even in this case the mother was already concerned and was in the process of seeking help. The authors conclude that "this school medical examination of first-grade children who had been previously examined before entrance was valueless from a case-finding standpoint."

Another significant though not surprising finding of this study was that a child with an adverse condition whose "school entrance" examination had been performed by his family physician was more likely (82 per cent of cases) to be receiving care than a child previously examined by a school physician (67 per cent of cases).

The dominant trend now seems to be to change the practice of annual mass physical examinations. "Even at the cost of performing fewer examinations, it is considered essential to establish a floor on quality below which the examiner will not descend."[4]

The shift of emphasis has been in the groups to come before the physician. The routine examination by family or school physician of entering children has largely been continued. In subsequent years major attention has been shifted to specially referred children from any grade. It is these specially referred children who are located by current school health screening techniques described later. In addition, a second routine examination might be desirable on or about the time of entry to Junior High School. This could have special reference to the important point of determining physical fitness for participation in strenuous competitive sports.

DAILY TEACHER OBSERVATION

The classroom teacher is the only person in the public service who maintains complete and continuous contact with children. This continuous and close contact is the characteristic which has determined the important part she plays in the school health program. Through careful observation the teacher can pick out very nearly all children with significant deviations from physical, mental, and social well-being, help to correct some of these by giving special attention to the child and his family, refer others for help, and follow up those referred in order to be sure that the needed help has been obtained. "Like the parents she has an opportunity to learn the characteristic appearance of each well child and so can detect changes in health status as they occur. But unlike the parents, who have eyes only for their own, she sees the individual differences of each child against a background of many other children. What a mother might explain or excuse with the remark, 'Oh, he has always been like that,' the teacher sees as a deviation from the behavior or learning ability of a group of children of approximately the same age."[6] As part of their basic training and in special workshops, teachers are being given the necessary orientation and background and are rapidly proving themselves to be adept in lowering their threshold of suspicion to those subtle changes in appearance or behavior and various symptoms and signs which suggest the need for a complete pediatric health appraisal. As a part of the cumulative school health record of each pupil they are supplied with a guide *Teachers Observation of Pupil's Health*[7] on which they can, from time to time, record their impressions for discussion with the nurse. This guide lists a variety of terms under several general headings which the teacher may check or comment on. For example, under "General Appearance" some of the items are "underweight", "overweight", "does not

appear well," "tires easily," and "excessive pallor." Under "Eyes" attention is drawn to "styes or crusted lids," "inflamed eyes," "crossed eyes," "squinting, frowning, or scowling," "rubbing of eyes," "holding head to one side," and other similar observations.

THE TEACHER-NURSE CONSULTATION

This is an informal meeting between the nurse and the classroom teacher, usually at the time of the public health nurse's visit to the school.[7] It may be initiated by either and is designed to talk over suspected illnesses or maladjustments *as soon as they are identified.* At these meetings, the public health nurse can frequently interpret previous medical findings or recommendations from clinics such as crippled children's diagnostic clinics. In addition she brings to the teacher knowledge that she may have of home conditions affecting the child's health. These meetings give the teacher opportunity to point out observations which she has made; and as a result of these "consultations" children are often "screened out" for referral to the family physician or the school clinic. The teacher-nurse consultation is also the foundation of close-working relationships between the school and the health department and creates the climate of joint partnership which facilitates other facets of the screening program.

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THE TEACHER-NURSE CONFERENCE*

In contrast to the consultation, the teacher-nurse conference is designed as an *annual* (or semiannual) *appraisal of the health of all of the children in the classroom.* The health of each individual child is discussed during this scheduled conference. The childrens' cumulative health records are carefully reviewed one by one, so that their past health history can be considered in relation to their present health status. Provision is usually made for substitute classroom help so that the teacher is free to spend time with each child during the conference.

All information available to teacher or nurse is pooled and evaluated at this time. This includes all or some of the following: previous health history, the teacher's observations, the nurse's knowledge of home conditions, graphic plotting of height and weight, audiometer test, vision test, x-ray screening report, plus certain inspections which are done on the spot including scalp and hair, eyes, ears, mouth and throat, speech, skin, posture, and general appearance.

From a mutual consideration of these data on each child, the teacher and the nurse have proved themselves in the opinion of the writer to be most astute and accurate case finders even for subtle and obscure illness. This fact has been well documented in the Washington County School Health Demonstration[8] where, except for routine examination of entering first-graders by the physician, the teacher-nurse referral based on objective and subjective screening has been relied on exclusively. This process has successfully ferreted out a mass of disease from ringworm of the scalp to brain tumors, enuresis to kidney tumor, hay

*Details of these procedures vary among the States. The plan here is the one used in Maryland, with which the writer is most familiar.

fever to bronchiectasis, constipation to Hirschsprung's disease, and mild behavior disorder to psychosis.

In this project, from a participating school population of 13,450, careful pediatric examinations were done on 1,103 children. Over 80 per cent of these were on the basis of teacher-nurse referral. The remainder were routine examinations of entering first-graders and those homebound children receiving instruction at home. Ninety per cent of the children referred by the teacher and nurse were found by the pediatrician to require some type of follow-up. A few examples will illustrate.

Of 437 children referred on the basis of teacher observation for ear, nose, or throat symptoms, 397 (91 per cent) were sent by the school pediatrician and the family physician to the Conservation of Hearing Clinic. Another 671 children were referred directly as a result of school audiometric tests. Thus, 1,068 (88 per cent) of the total of 1,214 new cases seen in this hearing diagnostic clinic over the two-year period resulted from the school screening process. Follow-up of this group included: 19 children hospitalized (13 for mastoidectomy, 4 for bronchiectasis, and 2 for removal of laryngeal tumor); 15 children sent to Baltimore medical teaching center clinics (9 to the Speech and Hearing Center where 7 hearing aids were prescribed, and 6 to allergy clinics); 293 tonsillectomies and/or adenoidectomies recommended (195 of these operations were completed with full or partial crippled children's program assistance; the number of remaining private cases completed not known); 242 children received antibiotic or other medical therapy; and 196 children received radium treatments.

Of the 122 new school children seen in the orthopedic clinic 98 (80 per cent) originated from the teacher-nurse screening process followed by examination by private or school physician. Twenty-one of these children were hospitalized. Among a total of 469 school children (old cases as well as new) seen in the orthopedic clinic in the two-year period studied, about 80 per cent were referred through the school health program on the basis of teacher-nurse referrals. One hundred and sixty-seven of these children received corrective appliances (118 corrective shoes and 49 a variety of orthopedic appliances).

In the judgment of the director of this project, the shift in emphasis from frequent routine medical examinations to more intensive diagnostic work-up and follow through on health problems identified by the screening process was largely responsible for the greater degree of success in obtaining the medical care needed.

VISION TESTING

Looking for signs of eye strain or symptoms of visual disturbance is an integral and important part of daily teacher observation of each child's health. Most school health programs stress the fact that testing of the eyes with a gadget in the hands of a technician in no way obviates the importance of the teacher's impressions on this score. It is the two things taken together, the subjective impressions and the objective testing, which are considered.

In 1948 and 1949, a detailed study to determine the efficiency of certain procedures commonly used or recommended for use in schools to screen children for visual defects was conducted in St. Louis.[9]

Six hundred and nine sixth-grade students and 606 first-grade students in the public schools were given a complete ophthalmologic examination and tested with certain vision screening procedures.

The screening procedures studied were: Teacher Judgment, the Snellen Test, a Near Vision Test using the Lebensohn or Guibor charts, the Massachusetts Vision Test, the Keystone View Company Telebinocular Test, combinations of some of these procedures, and, for sixth-grade students, two procedures developed for industry rather than in schools: the Bausch and Lomb Ortho-Rater and the American Optical Company Sight-Screener.

"The results of the study do not justify a conclusion that any one or two or three procedures are superior to all others for use on a screening program. As they are now set up, the Snellen and Massachusetts Vision Test give better agreement with clinical judgment than the others, but the procedures that include more measurements give a higher proportion of referrals and so miss fewer of the students who need care."

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In discussing the likely reasons as to why these methods of measurement are not more reliable, the report[9] goes on to say: " . . . it would seem to be that the understandable pressure to save time in administration of the tests is the root of the trouble. There are recognized methods of increasing the reliability of measurements, but these require devotion of more time to administering the tests. The emphasis on saving time has resulted in unsuccessful attempts to short-cut the complex measurement problems involved. Hope that even with the most ingenious instrument devisable, any visual function can be measured reliably by a quick check holds practically no promise of success, especially with children."

One of the important practical problems in the case of vision testing arises from the condemnatory attitude of some parents and some physicians with respect to needless referrals. In Maryland the point of view expressed by Scobee[10] has been found to be most helpful. He reminds physicians that ideally every child should have an ophthalmologic examination prior to beginning school. "Practically this is not possible. The next best thing is for the schools to do the best they can with the equipment they have in attempting to detect physical defects and call them to the attention of the parents. Such a program will obviously result in a certain number of needless referrals. The manner in which the ophthalmologist handles the needless referral can make a big difference in the relationships between family and school."

HEARING TESTING

What has already been said in the case of vision testing as to the value of the teacher's observations together with the results of the objective testing device applies with equal force to hearing. For example, in Maryland a high correlation has been established between hearing impairment and the kind of uncooperative behavior characterized by spit-ball throwing.

Currently both group and individual pure-tone audiometer testing is being performed in the schools. It is my impression that the latter is gaining favor for precisely the same reason, i.e., the futility of cutting corners, as described before in the St. Louis vision study.

The selection of grades to be tested varies with local circumstances; usually alternate grades are tested every year. The test procedure is called the "sweep-check."[7] The attenuator-control of the instrument is kept at 15 decibels. The test is begun with the frequency-selector set at 1,000 cycles; if the pupil can hear this tone (indicated by raising his index finger), the technician turns the tone control to 2,000 cycles and so on up to the highest frequency. This procedure takes about a minute and a half for each child. After each class has been screened, the technician rechecks the children who have failed. These children are tested much more carefully and in greater detail.

GRAPHIC RECORDS OF HEIGHT AND WEIGHT

Periodic recording of the height and weight of each pupil can be a part of good teaching of growth and development as well as a means of detecting growth failures.[11] Deviations from the expected rate of growth as individually determined can be taken as suggestive of some disturbance in the child's health and thus serve as an acceptable reason for referral for medical opinion.

In a recently published guide[12] for physicians on health supervision of young children, the American Public Health Association has suggested criteria which any method of graphic presentation of height and weight should fulfill.

1. It should depicit the child's own growth pattern.
2. It should relate the growth pattern of the individual child to a standard growth pattern derived from observations on a large number of children.
3. It should be simple to understand and easy to explain to parents and to older children.
4. It should be inexpensive and health agencies should be permitted to reproduce it for their own purposes.
5. It should either state or provide references to its original source, the data on which it is based, and its method of construction. Use of commerical graphs which are not based on published data is deprecated.

The percentile type of presentation is usually preferable. A satisfactory form* in wide use in school health programs is the "Physical Growth Record for Boys" and "Physical Growth Record for Girls" of the National Education Association and the American Medical Association.

OTHER SCREENING PROCEDURES

As a part of the educational program, a variety of testing for mental ability and reading readiness is performed. Currently there is interest in screening tests for "specific reading disability", but these efforts are in the experimental stage. Such tests are useful and are generally considered by the teacher and nurse along with other data.

*Obtainable from National Education Association, 1201 16th Street, N.W., Washington, D. C.

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Mass photofluororoentgenographic surveys are commonly carried out in the secondary schools, especially in the last two years of high school. Because of the negligible expectancy of tuberculosis in this age group, this cannot be said to be a screening procedure in the sense of case finding. Indeed it is most frequently justified on the basis of its health educational value among these future fathers and mothers.

Opinions vary on the value of tuberculin testing of school children. In Maryland the concensus is that this procedure has little value from the case-finding standpoint, but may be quite useful as an epidemiologic method to provide useful information on geographic levels of infection and for pin pointing what sections of the community should receive priority in tuberculosis control efforts. Tuberculin testing, if included as a screening measure, should only be done under the direct supervision of an experienced person. Great care should be taken to obtain standardized readings and to give parents a clear explanation of the meaning of positive tests, a point often causing confusion and unnecessary alarm. Because of the amount of personnel time involved, it is doubtful whether tuberculin testing is cheaper than mass x-ray surveys.

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Routine laboratory tests such as hemoglobin determination, urinalysis, or serologic test for syphilis are occasionally performed among selected groups or in geographic areas where there is a particular health problem. During the first year of operation of the Washington County School Health Demonstration, routine urine examinations were done. From the first 900 specimens only five showed abnormal findings and two of these were expected. Subsequently urinalyses have not been done routinely but only when indicated by other findings.

SUMMARY

Since World War II screening procedures have been re-emphasized in school health programs as a more realistic and effective method of locating children with health problems.

Coincidentally with this shift in emphasis there has been an effort to use the time of physicians for precise medical diagnosis, interpretation of the problems to the school staff, and formulation of a plan to carry out definitive treatment needed.

Current school health screening procedures are a judicious mixture of continuous subjective observation on the part of both classroom teacher and nurse and objective methods such as vision and hearing tests, graphic recording of height and weight, psychometric and reading readiness tests. The cumulative health record of each child is an important aspect of this process.

By and large, emphasis is on the observations of the nurse and teacher rather than on technicians and mechanical devices. Data from the latter are pooled with all other information and appraised by the teacher and nurse who then reach a decision as to whether or not to refer the child for further medical study by the family physician or the school clinic depending on the circumstances.

Experience in the Washington County School Health Demonstration and elsewhere strongly suggests that the emphasis on the type of screening process described is producing encouraging results in terms of the variety and number of pathologic conditions discovered, many of them in early stages. The shift in emphasis toward focusing the energy of the medical profession on careful definitive diagnosis, prompt treatment, and planning for a regimen of total care in long-term cases has been a most refreshing step forward.

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THE FUTURE OF THE MINIATURE CHEST X-RAY IN SCREENING FOR ASYMPTOMATIC DISEASE

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THE miniature chest x-ray as a device for finding abnormalities in the pulmonary parenchyma has had an interesting and vivid history. Since the autumn of 1895, when Roentgen discovered the x-ray and demonstrated its fluorescent and photographic applications, roentgenography of the chest has been one of the most useful procedures for detecting pulmonary tuberculosis and other abnormalities. The use of the x-ray as a diagnostic tool is not disputed, but its application as a case-finding device, particularly as applied to mass population groups, has many enthusiastic proponents and disputants.

Immediately after Roentgen's announcement of his epochal discovery, ingenious minds began to perceive that if x-ray methods could be economically and speedily applied to large groups, hidden cases of tuberculosis could be made manifest and put under early treatment.

Only six months after Roentgen's discovery, Bleyer[1] developed what he called the photofluoroscope, which he used to photograph the fluorescent image. MacIntyre[2] developed an improvement on Bleyer's device by means of which he prevented fogging of the photographic plates caused by direct radiation. Porcher,[3] in 1897, and Kohler,[4] in 1907, conducted experiments which on the one hand demonstrated the advantages of direct roentgenography, and, on the other, emphasized the practical potentialities of photography of the fluorescent image.

It was not until 1911, however, that experimental studies foreshadowed present-day photofluorographic techniques. Caldwell[5] in that year demonstrated that photography is much more effective than the eye in depicting images on the fluorescent screen. After Caldwell's work, which he promised would in the future be an instrument of great practical usefulness, other workers contributed to the refinement of this technique through their experiments with screens, lenses, and films.

Mass radiography advanced with marked acceleration with the development in 1931 of the rapid roll-film method which employed 14 by 17 inch sensitized paper. This development made it possible to produce films of uniform quality, which had not been possible through the use of prior methods.

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Between 1936 and 1938, de Abreu in Brazil, Franke and Holm in Europe applied 35 mm. photofluorography on a large scale for the first time. The device had become so efficient by that time, that in Germany one community of 640,000 persons was completely examined in three months. Also in this period, Potter[6] in the United States produced the photoroentgen unit using films 4 by 5 inches in size.

The success of the work done by these men was somewhat hampered by the lack of suitable large lenses of high speed that would give films added density and clarity. However, as soon as such lenses were available from work that had been going on concurrently in many parts of the United States and Europe, photofluorography was ready to be applied on a mass basis.

Hirsch,[7] of New York City, carried on extensive research with 35 mm. photofluorographic films between the years 1938 and 1940 and was able to produce excellent results in spite of the relatively slow speed of films of that time. Holm of Denmark, Chambers and Behrens,[8] Long of the Naval Medical School, Dearing and Turner[9] in Tennessee, Hilleboe and his co-workers[10] in Minnesota, all experimented with and used improved devices which gave great impetus to mass radiography in the United States.

In 1940, Potter, Douglas, and Birkelo[11] reported the comparative results of the photofluorographic with the standard radiographic method in a practical field survey which included hundreds of cases. They used the 4 by 5 inch photofluorogram and the 14 by 17 inch standard films which were taken and read independently and the readings compared. They found the small film method satisfactory for mass employment.

The first significant achievement of mass application of fluorography was dramatically exemplified during World War II in routine chest examinations of all men and women inducted into the Armed Forces. From 1941 to 1944, the first years of World War II, over 20 million photofluorograms were taken in the United States alone.

With the end of World War II and the release of photofluorographic equipment by the Armed Forces, state and local health departments and other health agencies started acquiring equipment and initiating a general x-ray campaign.

In 1944 and 1945, Hilleboe and his co-workers in the United States Public Health Service advanced a nationwide campaign for mass x-ray programs with the immediate objective of reaching a majority of the adult population of the United States. The purpose of this case-finding program was the discovery of hidden cases of tuberculosis so that they could be isolated, treated, and rehabilitated.

Through the efforts of health departments, tuberculosis associations, medical and professional organizations and institutions, mass radiography programs spread throughout the country. Many cities and counties carried on vigorous case-finding campaigns. The Public Health Service actively participated in such large-scale community-wide x-ray programs as those carried on in Minneapolis, Washington, Seattle, Cleveland, Denver, Boston, Los Angeles County, and several others (Table I). Public Health Service Publication No. 222 describes in detail the organization, methods, and results of community-wide chest

TABLE I. TUBERCULOSIS DIAGNOSED ON 25 COMMUNITY-WIDE CHEST X-RAY SURVEYS

SURVEY	TOTAL SATISFACTORY X-RAYS	TOTAL TUBERCULOSIS		ACTIVE TUBERCULOSIS			TUBERCULOSIS OTHER THAN ACTIVE		
		NUMBER	PER 1,000 X-RAYS	NUMBER	PER 1,000 X-RAYS	MONTHS FOLLOW-UP†	NUMBER	PER 1,000 X-RAYS	MONTHS FOLLOW-UP†
Minneapolis, Minn.	301,513	2,120	7.0	261	0.9	16	1,859	6.2	16
St. Paul, Minn.	125,853	516*	4.1	45	0.4	5	471	3.7	5
Washington, D. C.	439,927	4,277	9.7	393	0.9	8	3,884	8.8	8
Seattle, Wash.	367,732	976*	2.7	356	1.0	13	620	1.7	6
Tacoma, Wash.	72,703	134	1.8	35	0.5	3	99	1.4	3
Cleveland, Ohio	673,115	4,099	6.1	384	0.6	3	3,715	5.5	3
Spokane, Wash.	106,526	232	2.2	34	0.3	6	198	1.9	6
Denver, Colo.	324,096	4,231	13.1	366	1.1	9	3,865	11.9	9
Boston, Mass.	528,941	4,426	8.4	530	1.0	4	3,896	7.4	4
Salt Lake City, Utah	162,351	570	3.5	163	1.0	1	407	2.5	1
San Diego, Calif.	238,557	N.A.	—	222*	0.9	11	N.A.	—	—
Los Angeles, Calif.	1,736,703	13,100*	7.5	1,916	1.1	21	11,184	6.4	21
Contra Costa County, Calif.	121,434	816*	6.7	170	1.4	15	646	5.3	15
Phoenix, Ariz.	175,724	3,105	17.7	386	2.2	14	2,719	15.5	14
Albuquerque, N. Mex.	77,082	1,324	17.2	239	3.1	12	1,085	14.1	12
Willamette Valley, Ore.	234,809	516*	2.2	79	0.3	8	437	1.9	8
Southwest Washington	74,415	314*	4.2	34	0.5	5	280	3.8	5
Southern Oregon	66,147	N.A.	—	N.A.	—	—	N.A.	—	—
Portland, Ore.	234,723	1,177*	5.0	182	0.8	13	995	4.2	13
Dallas, Tex.	269,845	1,535*	5.7	283	1.0	15	1,252	4.6	15
Worcester, Mass.	152,260	467*	3.1	55	0.4	3	412	2.7	3
Lake Charles, La.	54,130	72*	1.3	10	0.2	4	62	1.1	4
Fresno, Calif.	164,537	505*	3.1	94	0.6	4	411	2.5	4
Charlotte, N. C.	106,060	393*	3.7	39	0.4	4	354	3.3	4
Pittsburgh, Pa.	856,002	4,481*	5.2	304	0.4	12	4,177	4.9	12

*Includes reports on previously unknown cases only.
†Months follow-up is the length of time during which follow-up was conducted.

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x-ray surveys in which the Public Health Service participated in taking more than 8.5 million miniature films. Special population groups with a high tuberculosis prevalence, such as migrant laborers, jail inmates, and mental hospital patients, have received intensive examinations by this means. In addition, many hospitals throughout the country have adopted miniature x-ray screening of admissions as a routine procedure.

The National Tuberculosis Association estimated that some 6 million chest x-rays were taken in our civilian population during 1946.[12] By 1953, state health departments reported 15.5 million.[13] This increase would not have been possible without widespread public acceptance of miniature film surveys.

In 1953, about a third of the newly reported cases of tuberculosis in this country were discovered as the result of these chest x-rays.[13] The yield of new cases in individual surveys has varied greatly from area to area, depending largely upon the kind of population examined, as well as upon the emphasis placed on follow-up of suspected lesions and diagnosis. In general, the findings on these surveys compare favorably with findings in community-wide chest x-ray surveys in which the Public Health Service participated, averaging nearly one active case of tuberculosis for every 1,000 examinations. This varied somewhat with the area surveyed and with the length of follow-up, as is shown in Table I. In addition to active cases of tuberculosis initially discovered, follow-up of cases thought to be inactive or for whom clinical activity could not be definitely established subsequently yielded many infectious cases. In one survey where the immediate yield of active disease was one case per 1,000, a two-year follow-up demonstrated active disease in 10 per cent of the group initially classified as inactive and 40 per cent of the "activity undetermined" group.[14] From this study as well as others it would appear that, with good follow-up, the two-year yield of active cases in chest x-ray programs would approach 2 per 1,000 examinations.

It will be noted on Table I that the total yield of tuberculosis from chest x-ray surveys has declined somewhat in the last five surveys. The first survey shown, in Minneapolis, was conducted in 1947, while the last, in Pittsburgh, was conducted in 1953. While there have been scattered reports from states showing no change or increasing yields in general population surveys, it seems reasonable that a decline should be taking place.

Chest x-ray surveys have in the past been justified largely as a tuberculosis control measure. Work reported by Davies[15] immediately after World War II demonstrated the probable potential of this technique in preventing the development of new cases of tuberculosis by discovery and isolation of unsuspected active disease. In a nearly complete x-ray survey of a community, only two cases of tuberculosis could be found which could be considered as new cases, having developed during the six years following the survey. Subsequent studies do not completely agree with these findings. Possibly this is so because tuberculosis not infrequently develops only years after infection and the low attack rate reported by Davies was exceptional. Indeed, many of today's cases are the result of infection that occurred before the time of x-ray surveys. Regardless of when the effects of these case-finding efforts are felt, however, a reduction in

the rate of infection doubtless occurs as a result of discovery and treatment of tuberculosis before it ordinarily would have been brought to medical attention.

Part of the justification of chest x-ray surveys has also been that benefits accrue to the individual as the result of early discovery of the tuberculous process. Many have accepted this a priori, both in case finding for tuberculosis and in case finding for many of the other chronic diseases. Some evidence for this in tuberculosis has been presented in a retrospective study of one of the early community-wide chest x-ray surveys in which the Public Health Service participated.[16] It is of interest that there did appear to be some relationship between the extent of x-ray campaigns during the period 1947 to 1950 and the decline in the tuberculosis death rate during this same period in various sections of the country.[17] Although this relationship is not conclusive evidence of cause and effect, it seems likely that the two effects of surveys mentioned were involved.

As yet no argument of sufficient cogency has been advanced to justify the immediate or imminent cessation of mass x-ray surveys as a tuberculosis control measure. The full effectiveness of mass x-ray surveys has frequently been vitiated by inadequate follow-up, insufficient numbers of hospital beds, clinics, laboratories, and shortages of personnel. Although these factors are still troublesome, we have now in fast-acting drugs the means and opportunity to place new cases under treatment immediately with good prospects of success. There is no longer need to wait for vacant beds while disease advances. Indeed, it may well be that the new drugs and their ready availability constitute the strongest argument we have ever had, not only for the continuation, but also for the expansion and intensification of mass surveys by miniature x-ray for tuberculosis. We know that these drugs work best on early cases of tuberculosis, precisely the type that chest x-ray surveys uncover. In fact, for that group the drugs are nearly 100 per cent effective. Were these same cases allowed to proceed on to more advanced and more symptomatic stages, it is quite certain that drug therapy would be more lengthy and less effective.

From the introduction of the miniature film survey until the present, a number of changes have taken place in our population which have tended to enlarge our concepts of public health and needs for community effort. Largely because of a decline in the death rate from the infectious diseases, an increasing proportion of our population is reaching the older ages. This in turn has given rise to an increasing prevalence of such chronic diseases as cancer and heart disease. During the same period there has also been an increase in lung cancer and possibly in certain types of heart disease which cannot be explained by the aging of our population. The miniature chest x-ray is capable of detecting many of these conditions in a stage when treatment can be more beneficial and when it can do more to prevent disability and death.

There have been some reports on the yield of chest x-ray in detecting heart disease and lung cancer. One such report, by Guiss,[18] presents the results of the 1950 Los Angeles County mass x-ray survey, in which 1,867,201 persons were examined, not only for evidence of tuberculosis but also for signs of pulmonary neoplasms. Out of the total number, 3,500 chest-neoplasm suspects were placed

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in a "Chest Tumor Registry" for study and follow-up. After four years of study and an examination of the literature for bases of comparison, Guiss comes to this conclusion: "The evidence gathered in this study indicates that until some superior method is available, survey detection followed by prompt surgery is the only technique offering substantial increase of salvage for lung cancer at the present time."

In his discussion, Guiss asserts: "The only way at present to cure lung cancer is to operate in the silent or preclinical phase and the only method at present to detect bronchogenic carcinoma while silent is by roentgenographic survey. It seems more practical to foot the bill for the survey and cure a reasonable percentage of the patients discovered than to wait until symptoms appear, proceed through the same expensive measures of diagnosis and surgical treatment, and then have few or no cures to show for the effort and money involved."

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Despite reports such as this, we must acknowledge that the amount of lung cancer and certain other chronic conditions revealed in the past by chest x-ray surveys, which can be treated successfully, has not provided a strong justification for aggressive case finding for these conditions.

Against this background, we need now to consider the future of miniature chest x-ray examinations. Certainly, in the immediate future they will continue to be a vital part of tuberculosis control effort. As we gain in the fight against this disease, however, there will come a time when the amount of undetected tuberculosis to be discovered is too small to justify the expense involved in wide-scale case-finding efforts by chest x-ray surveys on the basis of tuberculosis control alone. True, this relatively small group of infectious cases will probably represent the most important group of cases for detection, for therein will lie the means for spread of the tubercle bacillus among human beings. But from a practical standpoint, if these cases are to be uncovered by mass x-ray examinations, some other benefits must be derived that will justify continued mass examination of our population.

With regard to the nearly 16 million chest x-rays taken in this country during 1953, the Public Health Service has fairly good data on the numbers considered positive for tuberculosis as well as the numbers finally discovered with this disease. This is a tribute to the interest in x-ray as a tuberculosis control measure; to the tuberculosis record systems which are established in conjunction with surveys and which help ensure that each suspect gets to a physician for clinical evaluation; to the public health nurse who visits these persons and helps with arrangements for treatment and medical care. It is understandable that we do not have data on what x-ray surveys produce in terms of other chest conditions such as heart disease and lung cancer. Drawing upon experience of the Public Health Service in community-wide chest x-ray survey programs, it would not be unrealistic to guess that they produced much less than they should have. In the chest x-ray surveys shown in Table I, the primary objective was the discovery of tuberculosis, and examinations of individual photofluorograms stressed this. While much heart disease, lung cancer, and other diseases were identified, much additional disease was undoubtedly

overlooked. In one survey (Boston) when a study of cardiovascular abnormalities was proposed, the regular survey readers apparently changed their recall rate for cardiovascular abnormalities—from 4 per 1,000 x-rays to 11 per 1,000. Despite this, careful re-examination of these same x-rays by special readers revealed an additional 24 positive films (for cardiovascular disease) per 1,000 examinations—making a total of 35 x-rays positive for cardiovascular disease per 1,000 examinations. This group of films ultimately produced 16.2 cases of verified heart disease out of each 1,000 x-ray examinations, of which 9.0 were previously unknown.[19] A study of the group of films for which regular survey readers were recalling only four cardiovascular suspects per 1,000, revealed 2.3 cases of verified heart disease per 1,000 x-rays, of which only 0.7 were previously unknown.[20] Thus it would appear that by reading more closely for cardiovascular abnormalities, the yield of miniature film surveys might be increased from less than one previously unknown case per 1,000 x-rays to nine cases per 1,000 x-rays. It is probably significant that the over-all recall rate of 35 per 1,000 films approached the rate of 50 per 1,000 observed on a multiple screening program at Richmond, Virginia, where miniature films received a special reading for cardiovascular abnormalities.[21] This higher reading and discovery rate seems, therefore, generally attainable, although smaller yields have been reported despite intensive reading,[22] possibly due to differences in the age distribution of the population involved.

If the potential of x-ray surveys is to be exploited as a case-finding procedure for heart disease, one of the important questions to be answered is what proportion of the existing heart disease is identifiable by chest x-ray. Estimates of this range from 4 per cent[23] to 45 per cent.[24] Kurlander, Hill, and Enterline report that of the known heart disease and/or hypertension in a group of hospital outpatients, 54.1 per cent was detected by miniature chest x-rays, while 34.2 per cent of the previously unknown disease was so detected.[25] The basic difference between the low estimate of 4 per cent and the higher estimates appears to be in the type of film reader and the setting in which the film reading was made. In obtaining the 4 per cent estimate, miniature chest x-rays were taken in a tuberculosis clinic and read by a chest physician without knowledge that the patient was part of a heart study. In the case of the higher estimates, the film readers were radiologists who were well aware of the purpose of the study in which they were participating.

For lung cancer, we have evidence also to suggest that much may be missed on chest x-ray surveys as they are now conducted. In San Diego, for example, a check of lung cancer cases and deaths against the files of a community-wide chest x-ray survey conducted there in 1950 showed that of 24 individuals who had films read as "negative" in the survey and who later died of lung cancer, six had films that probably should have been called positive and four of these six were entitled to be classified as neoplasm suspects from the gross 70 mm. findings.[26]

There is now ample evidence that miniature film surveys can be made more productive in the efforts to control disease in addition to tuberculosis. Such

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improvement would no doubt overcome many of the objections now voiced against this technique, most of which are based on the low rate of "salvageable" disease uncovered. This increase in productivity can be brought about in two ways: by improving film interpretation procedures and by providing an intensive follow-up for all disease suspects. This latter suggestion has, in fact, already been made by the national organizations devoted to the control of tuberculosis and heart disease.[27] To improve film interpretation, all films should be read at least twice. This should increase the yield of tuberculosis as well as other diseases. During the time the Public Health Service participated in community-wide chest x-ray surveys, miniature films were read twice on several occasions. In Charlotte, North Carolina, for example, where dual reading was done during the latter part of the x-ray survey, 22 active cases were picked up by the first reader and four were added by the second. Our experience essentially confirmed that reported in other studies in so far as the detection of tuberculosis is concerned.[28,29] Unfortunately, there are no data from Public Health Service experience on the amount of confirmed disease other than tuberculosis, added by a second reading. However, the principles involved are such that similar benefits can be predicted for multiple interpretation of films when other diseases are sought.

DISCUSSION AND SUMMARY

During the next few years miniature chest x-ray programs have much to contribute to the control of tuberculosis. Now, probably more than ever before, we should pursue these campaigns vigorously so that every active case may receive the benefits of new, more effective treatments, and so that chains of infection can be broken and the disease finally eradicated. In prosecuting the program to date, however, we have been inclined to neglect the potentialities of chest x-ray as a case-finding device for other diseases, which are becoming increasingly important as public health problems and which are deserving of our best efforts. In part, our neglect has stemmed from "under-reading" which has resulted in a relatively low yield of heart disease and lung cancer cases that can be benefited. Data are available which show that the yield in terms of heart disease could probably be increased at least ninefold and that additional lung cancer could also be uncovered. To do this, films must be examined more carefully by at least two readers, and with particular attention to cardiovascular shadows. Moreover, follow-up programs which will lead to definitive diagnosis and medical care should be instituted for all conditions seen, not just for tuberculosis alone. If this is done, miniature film x-ray units can become a real service associated with better health for many people.

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AN EVALUATION OF SOME COMMONLY USED SCREENING TESTS FOR HEART DISEASE AND HYPERTENSION

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AS PART of a multiple screening study conducted at the District of Columbia General Hospital from Jan. 23, 1952, to Oct. 24, 1952, four commonly used screening tests for heart disease and hypertension were evaluated. The procedure followed was to apply the four screening tests (chest x-ray read for heart abnormalities, history, electrocardiogram, and blood pressure determination) to each person reporting to the screening line and also to perform a complete cardiovascular examination on each of these persons. The results of the screening tests were withheld from the diagnostic facility which performed the cardiovascular examination. Thus, the screening tests were applied to a population for which the presence or absence of cardiovascular disease was independently determined. It was possible, therefore, to measure the degree to which the tests could distinguish between the presence or absence of heart disease or hypertension.

A total of 858 persons went through the multiple screening line and also received a complete diagnostic examination for cardiovascular disease. Only 690 of the 858 received all four of the cardiovascular screening tests, however. All of the data presented in this report relate to these 690 persons unless otherwise specified. Of these 690 persons, 233 were diagnosed as having heart disease or hypertension (or both). An additional 32 persons were diagnosed as having some form of peripheral vascular disease or abnormality without heart involvement or hypertension. For the evaluation of screening tests described here these persons are considered as negative, since the screening tests being evaluated are not ordinarily used to identify such conditions.

This is the second in a series of reports describing the results of a multiple screening study conducted at the District of Columbia General Hospital. The first report appeared in *Diabetes*, The Journal of the American Diabetes Association, "Screening Tests for Diabetes," May-June, 1954.

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TABLE II. DIAGNOSES ESTABLISHED BY THE MEDICAL DIAGNOSTIC CLINIC BY AGE AND SEX

DIAGNOSES	TOTAL						MALE						FEMALE					
	ALL AGES		UNDER 40		40 AND OVER		ALL AGES		UNDER 40		40 AND OVER		ALL AGES		UNDER 40		40 AND OVER	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
Total persons	690	100.0	314	100.0	376	100.0	229	100.0	69	100.0	160	100.0	461	100.0	245	100.0	216	100.0
Diagnosed negative for heart disease and hypertension	457	66.2	279	88.9	178	47.3	147	64.2	62	89.9	85	53.1	310	67.2	217	88.6	93	43.1
Diagnosed heart disease and/or hypertension	233	33.8	35	11.1	198	52.7	82	35.8	7	10.1	75	46.9	151	32.8	28	11.4	123	56.9
Total cases of heart disease or hypertension*	265	100.0	36	100.0	229	100.0	98	100.0	7	100.0	91	100.0	167	100.0	29	100.0	138	100.0
Heart Disease	192	72.5	21	58.3	171	74.7	76	77.6	5	71.4	71	78.0	116	69.5	16	55.2	100	72.5
Arteriosclerotic heart disease	59	(22.3)	2	(5.6)	57	(24.9)	27	(27.6)	1	(14.3)	26	(28.6)	32	(19.2)	1	(3.4)	31	(22.5)
Hypertensive heart disease	113	(42.6)	11	(30.6)	102	(44.5)	41	(41.8)	3	(42.8)	38	(41.7)	72	(43.1)	8	(27.6)	64	(46.4)
Rheumatic heart disease	5	(1.9)	3	(8.3)	2	(0.9)	2	(2.0)	1	(14.3)	1	(1.1)	3	(1.8)	2	(6.9)	1	(0.7)
Syphilitic heart disease	9	(3.4)	1	(2.8)	8	(3.5)	5	(5.1)	—	——	5	(5.5)	4	(2.4)	1	(3.4)	3	(2.2)
Heart disease, unknown etiology	6	(2.3)	4	(11.1)	2	(0.9)	1	(1.0)	—	——	1	(1.1)	5	(3.0)	4	(13.8)	1	(0.7)
Hypertension	73	27.5	15	41.7	58	25.3	22	22.4	2	28.6	20	22.0	51	30.5	13	44.8	38	27.5

*Some individuals counted more than once if more than one condition present.

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The population on which this study is based was composed of outpatients coming to a municipal hospital. These patients had sought medical attention because of symptoms not necessarily related to heart disease. All had been screened by questioning and cursory examination by an Admitting Office physician before coming to the Medical Diagnostic Clinic of the Out-Patient Department and had been referred because of signs or symptoms indicating the possibility of some serious disease. They were medically indigent, being required to meet strict standards in this respect. Some were former patients, but none of these had had a diagnostic clinic evaluation within a year. The group was predominantly Negro (87 per cent) and predominantly female (67 per cent), and contained relatively few young people. Details as to sex, race, and age, of the 690 persons in the study group are shown in Table I.

TABLE I. NUMBER OF PERSONS WITH COMPLETE SCREENING AND DIAGNOSTIC STUDY BY AGE, SEX, AND RACE

AGE GROUP	TOTAL	MALE			FEMALE		
		TOTAL	WHITE	NEGRO	TOTAL	WHITE	NEGRO
All ages	690	229	37	192	461	54	407
15–19	39	14	1	13	25	2	23
20–29	115	18	1	17	97	6	91
30–39	160	37	—	37	123	9	114
40–49	160	60	11	49	100	12	88
50–59	112	50	13	37	62	16	46
60 and over	104	50	11	39	54	9	45

As was to be expected in such a population, a relatively large percentage (34 per cent) were diagnosed as having a heart disease and/or hypertension. This is shown in Table II. Hypertensive heart disease was the condition most frequently diagnosed, making up 42.6 per cent of the total cases. Arteriosclerotic heart disease was the second most frequent type of heart disease diagnosed.

THE SCREENING PROCEDURE

Listed below are descriptions of the methods used and criteria for positivity for the four screening tests:

Blood Pressure.—This was taken in a sitting position (one reading only) by a technician. A systolic pressure of 150 mm. Hg or higher, or a diastolic pressure of 90 mm. Hg or higher was considered positive. The diastolic reading was taken at disappearance of sound.

History.—During the first half of the program, a physician queried the screenees concerning history of certain cardiovascular symptoms. The physician covered four categories routinely: history of rheumatic fever, dyspnea, orthopnea, and chest pain. The physician was able to develop each category as he saw fit, according to the screenees' responses, and to determine the significance of the answer. An affirmative response for any category was considered positive. This procedure for obtaining the screenees' histories was changed after 310

individuals had been screened. Subsequently, a series of questions was devised to be asked by a clerk. A copy of the form used is shown in Exhibit 1. The following criteria for positivity in this list of questions were strictly adhered to:

EXHIBIT 1

CARDIOVASCULAR HISTORY FORM

	Yes	*No*
1. Has any doctor ever told you:		
(a) That you had heart trouble?	_____	_____
(b) That you had high blood pressure?	_____	_____
(c) If so, what was the date of your last visit for this condition? _____		
2. Have any of your parents, brothers, or sisters, ever had heart trouble?	_____	_____
3. Have any of your parents, brothers, or sisters, ever had high blood pressure?	_____	_____
4. Have any of your parents, brothers, or sisters, ever had rheumatic fever, inflammatory rheumatism, or St. Vitus Dance? (underline which)	_____	_____
5. Have you ever had:		
(a) Rheumatic fever, inflammatory rheumatism, or St. Vitus Dance? (underline which)	_____	_____
(b) Red, swollen, tender, joints? If so, (either a or b) about how old were you?	_____	_____
(c) At the time of your first attack? _____		
(d) At your last attack? _____		
6. Do you ever have trouble in getting your breath? (short-winded)—If so	_____	_____
(a) While sitting still?	_____	_____
(b) On slight effort?	_____	_____
(c) From walking up one flight of stairs?	_____	_____
(d) Has your shortness of breath gotten any worse during the past year?	_____	_____
7. Does shortness of breath cause you to have trouble in sleeping?	_____	_____
8. How many pillows do you use at night? 4____; 3____; 2____; 1____; 0____.		
9 Have you ever had pain in the chest or chest discomfort?	_____	_____
(a) When does it occur? _____		
(1) While at rest		
(2) When walking fast		
(3) When hurrying, as for a street car (running)		
(4) When excited or angry		
(5) Other (specify _____)		
(b) How long does it last? _____		
(1) A split second		
(2) Under 5 minutes (but more than split second)		
(3) Five minutes to an hour		
(4) Over an hour to all day		
(5) Longer than 1 day		
(c) How often has it occurred? _____		
(1) Once only		
(2) Several times		
(3) Date of last attack _____		

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(d) What does it feel like? _____
  (1) A sharp, knifelike pain
  (2) A dull ache
  (3) A squeezing or pressure sensation
  (4) Other (specify _____)
(e) Where is it located? (point with one finger)
  (1) In the center of the chest (behind breast bone)
  (Use this code if pain located here at any time regardless of other locations)
  (2) Over the heart (left chest)
  (3) Other (specify _____)
(f) Does the pain move to any other area? _____
  (1) No, it stays in chest
  (2) To shoulder
  (3) To left arm
  (4) Other (specify _____)

Questions 1 through 4, and question 7, were not used in determining positivity. If, in question 5 (history of rheumatic fever), (a) or (b) was answered affirmatively, the screenee was considered positive. If, in question 6 (dyspnea), the answer was "yes" to both the main question and subquestion (c), the screenee was considered positive. In question 8, (orthopnea) if three or more pillows were used, the screenee was considered positive. In question 9 (chest pain), the screenee was considered positive only if an affirmative answer was given to the main question *plus* all of the following additional affirmative answers: (a) 2 *or* 3, (b) 2 *or* 3, (d) 3, and (e) 1.

Electrocardiogram.—This test was performed with the Standard Lead I only, taken in a sitting position. The electrodes were secured around the right and left index fingers with clamps which were permanently attached to the instrument leads. While the electrocardiogram was being taken, the screenee touched his thumb with the index finger. Use of digitalis was recorded on the electrocardiogram tracing in answer to the query: "Do you use any heart pill regularly?" The criteria for positivity were those recommended as abnormal or doubtful by Dawber and his associates.[1] A copy of these criteria is shown in Exhibit 2. All electrocardiograms were reviewed by a board-certified internist.

EXHIBIT 2

CRITERIA FOR POSITIVITY ON LEAD I ELECTROCARDIOGRAM

	Abnormal Feature
P Wave	1. Inverted
	2. Height—1.1 mm. or over
	3. Width—0.11 sec. or over
	4. Notched
	5. Biphasic
	6. Isoelectric
P-R Interval	7. 0.20 sec. or over
Q Wave	8. Width—0.04 sec. or over
	9. Depth—1.5 mm. or over

QRS Interval	10.	0.11 sec. or over
R Wave, height	11.	Under 1.5 mm.
	12.	15 mm. and over
S Wave, height	13.	Greater than R, unless low voltage
S-T Segment, deviation	14.	1 mm. or more deviation above or below base line
T Wave, amplitude	15.	Inverted
	16.	Isoelectric
	17.	Biphasic
	18.	0.8 mm. or less
Rate	19.	120 or over
Rhythm	20.	AF or flutter
	21.	PAT
	22.	PVT
	23.	Heart block
	24.	Multifocal or coupled rhythm

Note: Bradycardia of any degree is normal, except in presence of heart block (No. 23)
VPB's—Normal, unless multifocal or coupled rhythm (No. 24)
Wandering pacemaker and occasional VPB and APB—Normal.

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X-ray.—The first 244 individuals were screened by 35 mm. x-ray. Subsequently, the machine was converted to 70 mm. The x-ray machine was standardized at a 36 inch distance between the x-ray tube and camera hood and was not changed during the program. The time used was 0.2 to 0.3 second. The x-rays were read for cardiovascular abnormalities and other chest abnormalities by a board-certified radiologist. The types of findings which were considered abnormal are shown in Table III along with the frequency of these abnormal x-ray findings on a total of 713 persons who received chest x-rays.

TABLE III. CARDIOVASCULAR ABNORMALITIES SEEN ON SCREENING X-RAYS SHOWING FREQUENCY FOR 713 PERSONS X-RAYED

X-RAY IMPRESSION		NUMBER
Heart enlarged only		47
One diameter	10	
Both diameters	37	
Abnormal vessels only		29
Aorta calcified or arteriosclerotic with or without widening or tortuousness	19	
Aorta widened with or without tortuousness	5	
Aorta tortuous, unfolded, or knob prominent	3	
Pulmonary artery region prominent	2	
Heart enlarged and abnormality of vessels		76
Aorta calcified or arteriosclerotic with or without widening or tortuousness	42	
Aorta widened with or without tortuousness	23	
Aorta tortuous, unfolded, or knob prominent	6	
Pulmonary artery region prominent	1	
Not specified	4	
Heart enlarged with abnormal configuration		1
Heart enlarged with pulmonary congestion		1
Other abnormality		2

THE DIAGNOSTIC PROCEDURE

The D.C. General Hospital functions as a teaching hospital for the medical schools of Georgetown and George Washington Universities. It is approved by the American Medical Association as a teaching hospital and for specialist training in all clinical specialties. The Director of the Out-Patient Department is a board-certified internist. The Medical Diagnostic Clinic, where all diagnoses of heart disease or hypertension were established, performs diagnostic work for the Out-Patient Department in suspected or definite cardiac cases before they are referred to the Cardiac Clinic. The diagnostic study in the Medical Diagnostic Clinic was basically alike for all patients. It consisted of a complete history and physical examination, a series of routine laboratory tests, and special tests and examinations as indicated. As stated previously, screening results were not communicated to the Medical Diagnostic Clinic.

Three and one-half hours were allowed for the routine examination of each patient, with only two patients per day being scheduled for a physician. The patient was first given a complete examination by an intern or student, after which the entire procedure was repeated independently by the resident responsible for checking the former's findings. In cases of doubt or disagreement, another resident, or the Chief of the Out-Patient Department, or both, saw the patient before a final diagnosis was made. In some cases, specialists from other clinics also consulted. If procedures were desired which required more time, the examination was continued on another day.

The following tests or procedures were done routinely on all patients seen by the Diagnostic Clinic: hemoglobin determination, red and white cell counts and differentials, hematocrit determination, serologic test for syphilis, urinalysis, and a 14 by 17 inch chest x-ray. In addition, an electrocardiogram of 12 leads was routinely taken on all patients suspected of having heart disease and on all men over 45 and women over 55 years of age.

Other tests were used as indicated by suspicious symptoms or findings. In the field of cardiovascular disease the Department is completely equipped for the performance of exhaustive diagnostic procedures such as angiocardiography, ballistocardiography, cardiac catheterization, vectorcardiography, and differential pulmonary function tests.

The diagnostic criteria used were those recommended by the New York Heart Association[2] with the exception of criteria for the diagnosis of hypertension. The diagnosis of hypertension was based on four or more blood pressure readings taken on more than one occasion and was made only if all readings showed a consistent systolic pressure of 150 mm. Hg or more, or a diastolic pressure of 100 mm. Hg or more, and if there was no evidence of cardiac involvement.

EVALUATION OF SCREENING TESTS

In analyzing the results of the screening tests, the validity of the tests has been expressed in terms of their sensitivity and their specificity. A valid test should identify a large percentage of the cases of disease present in the population. This factor is called sensitivity and is measured by the percentage of all diag-

nosed cases that are screened positive by a particular test. A valid test should also properly identify a large percentage of the persons without disease. This factor is called specificity and is measured by the percentage of the persons without disease that are screened negative by the test in question. Sensitivity and specificity are useful factors in the evaluation of screening tests since these measures are independent of the prevalence rate of the condition being screened for in the population used in the evaluation. Thus, the results of validation of screening tests expressed in terms of sensitivity and specificity ratings provide a fairly good index of how the tests would perform in populations having various prevalence rates.

Taking the battery of four screening tests together, with the screening levels and criteria set as previously described, one or more of the tests were positive in 225 of the 233 persons diagnosed as having heart disease or hypertension, a sensitivity of 96.6 per cent. On the other hand, all tests were negative in only 146 of the 457 persons without heart disease or hypertension, so that the specificity rating of the battery of tests as a whole was only 31.9 per cent. This is shown in Table IV.

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TABLE IV. SENSITIVITY AND SPECIFICITY OF INDIVIDUAL SCREENING TESTS IN IDENTIFYING HEART DISEASE AND/OR HYPERTENSION

TEST	ALL SCREENEES			DIAGNOSED HEART DISEASE AND/OR HYPERTENSION			DIAGNOSED NEGATIVE FOR HEART DISEASE AND HYPERTENSION		
	TOTAL PERSONS	POSITIVE ON SCREENING		TOTAL PERSONS	POSITIVE ON SCREENING		TOTAL PERSONS	NEGATIVE ON SCREENING	
		NO.	%		NO.	% (SENSITIVITY)		NO.	% (SPECIFICITY)
Total Battery	690	536	77.7	233	225	96.6	457	146	31.9
Blood Pressure	690	320	46.4	233	201	86.3	457	338	74.0
History	690	318	46.1	233	126	54.1	457	265	58.0
Physician	310	182	58.7	95	68	71.6	216	102	47.2
Clerk	380	136	35.8	138	58	42.0	241	163	67.6
ECG	690	225	32.6	233	118	50.6	457	350	76.6
X-ray	690	147	21.3	233	111	47.6	457	421	92.1
35 mm.	244	32	13.1	78	25	32.1	166	159	95.8
70 mm.	446	115	25.8	155	86	55.5	291	262	90.0

Of the individual screening tests, blood pressure proved to be the most sensitive in pointing out persons with heart disease or hypertension. The sensitivity rating for blood pressure was 86.3 per cent and the specificity rating was 74.0 per cent.

Screening by history gave a sensitivity rating of 54.1 per cent and specificity rating of 58.0 per cent when the results of the history taken by the physician and by the clerk are combined. There are significant differences in the results by the two types of history, however. The history as taken by the physician proved to be more sensitive but less specific than that taken by the clerk. Of 95 persons with heart disease or hypertension in the group interviewed by the physician,

71.6 per cent were recorded as giving positive histories, while only 42.0 per cent of the 138 such persons in the group interviewed by the clerk gave positive histories. Of the persons without heart disease or hypertension, the physician recorded negative histories in only 47.2 per cent of those interviewed. (It should be noted, however, that 80 per cent of the nonheart disease and nonhypertensive cases giving a positive physician history were later diagnosed as having other conditions associated with dyspnea.) The clerk recorded negative histories in 67.6 per cent of the negative persons he interviewed.

The single lead electrocardiogram gave a sensitivity rating of 50.6 per cent and specificity rating of 76.6 per cent when applied to total heart disease and hypertension findings.

When the results of both the 35 and 70 mm. x-rays are combined, x-ray screening shows a sensitivity rating of only 47.6 per cent, but a specificity rating of 92.1 per cent. There were significant differences in the results secured with the two sizes of films. The 35 mm. appeared to be slightly more specific than the 70 mm. (96 per cent versus 90 per cent) but considerably less sensitive (32 per cent versus 56 per cent).

On many screening projects for heart disease or hypertension, more than one test might be used. Table V shows the relative sensitivity and specificity of various combinations of two of the four tests and various combinations of three of the four tests where a positive result on any test is considered as positive for the combination. Combining tests increases sensitivity considerably, with the combination of blood pressure and history identifying 93.1 per cent of the cases of heart disease or hypertension and the combination of blood pressure, electrocardiogram, and history identifying 96.1 per cent. It should be noted,

TABLE V. SENSITIVITY AND SPECIFICITY OF COMBINATIONS OF HEART DISEASE AND HYPERTENSION TESTS

TEST	ALL SCREENEES			DIAGNOSED HEART DISEASE AND/OR HYPERTENSION			DIAGNOSED NEGATIVE FOR HEART DISEASE AND HYPERTENSION		
	TOTAL	*POSITIVE ON SCREENING		TOTAL	*POSITIVE ON SCREENING		TOTAL	NEGATIVE ON SCREENING	
		NO.	%		NO.	% (SENSITIVITY)		NO.	% (SPECIFICITY)
Combination of Two Tests:									
B.P. and history	690	475	68.8	233	217	93.1	457	199	43.5
B.P. and ECG	690	418	60.6	233	215	92.3	457	254	55.6
B.P. and x-ray	690	349	50.6	233	211	90.6	457	319	69.8
ECG and history	690	429	62.2	233	180	77.3	457	208	45.5
History and x-ray	690	385	55.8	233	169	72.5	457	241	52.7
ECG and x-ray	690	291	42.2	233	157	67.4	457	323	70.7
Combinations of Three Tests:									
B.P., ECG, history	690	526	76.2	233	224	96.1	457	155	33.9
B.P., ECG, x-ray	690	436	63.2	233	220	94.4	457	241	52.7
B.P., history, x-ray	690	489	70.9	233	219	94.0	457	187	40.9
ECG, history, x-ray	690	459	66.5	233	191	82.0	457	189	41.4

*Positive on any one of the tests in the combination.

however, that this increase in sensitivity is at the expense of considerable specificity.

In all of the foregoing, screening tests were evaluated in terms of their ability to differentiate between persons with heart disease or hypertension and persons without heart disease or hypertension. It was shown that the four tests and combinations of these tests varied considerably in their ability to do this. As might be expected, these tests also varied in their ability to detect various types of heart disease as is shown on Table VI. Here only sensitivity ratings are shown since, a priori, the tests evaluated could not be considered as designed to identify only one type of heart disease or hypertension. For example, a specificity rating for blood pressure in sorting out hypertensive heart disease would be meaningless since it would imply that screening blood pressure should be negative on all persons with cardiovascular disease other than hypertensive heart disease, as well as in those with no cardiovascular disease. That is of course not so, since abnormal cardiovascular conditions other than hypertensive heart disease may cause an elevated blood pressure. Only three diseases classifications—hypertensive heart disease, arteriosclerotic heart disease, and hypertension—are shown in Table VI due to the small numbers involved in the other heart conditions diagnosed (see Table II).

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TABLE VI. SENSITIVITY OF INDIVIDUAL SCREENING TESTS BY TYPE OF HEART DISEASE OR HYPERTENSION*

TEST	ARTERIOSCLEROTIC HEART DISEASE			HYPERTENSIVE HEART DISEASE			HYPERTENSION		
	TOTAL CASES	POSITIVE ON SCREENING		TOTAL CASES	POSITIVE ON SCREENING		TOTAL CASES	POSITIVE ON SCREENING	
		NO.	% (SENSITIVITY)		NO.	% (SENSITIVITY)		NO.	% (SENSITIVITY)
Total Battery	59	59	100.0	113	112	99.1	73	71	97.3
Blood pressure	59	49	83.1	113	109	96.5	73	63	86.3
History	59	33	55.9	113	70	61.9	73	32	43.8
ECG	59	42	71.2	113	63	55.8	73	27	37.0
X-ray	59	37	62.7	113	64	56.6	73	21	28.8

*Conditions having fewer than 10 patients so diagnosed are not shown.

As is shown in Table VI, no cases of arteriosclerotic heart disease were missed by the battery of screening tests despite the fact that sensitivity for individual tests ranged from 55.9 per cent for history to 83.1 per cent for blood pressure. There was a considerable difference between the two types of history in detecting arteriosclerotic heart disease. For those persons interviewed by the physician, the history was positive in 90 per cent, while for those interviewed by the clerk the history was positive in only 37 per cent.

The high percentage of positive blood pressures among persons with arteriosclerotic heart disease (83 per cent) is partially explained by the concomitance of hypertensive heart disease or hypertension and arteriosclerotic heart disease

in 30 persons. Even when these are excluded, however, blood pressure was above the screening level in 70 per cent of the persons in which arteriosclerotic heart disease was the only diagnosis.

SENSITIVITY OF TESTS IN DETECTING PREVIOUSLY UNKNOWN HEART DISEASE OR HYPERTENSION

For use in actual screening projects it is of major importance that a test be valid in the detection of previously unknown heart disease or hypertension. Of the 233 persons with heart disease or hypertension diagnosed, 76 (33 per cent) were previously unknown. "Previously unknown" is defined as those persons who, when interviewed in the diagnostic clinic, indicated that they were unaware of their condition and who were previously unknown as a case to the Out-Patient Department of the D.C. General Hospital. Sixty-eight of these 76 persons had only one condition diagnosed, seven had two conditions diagnosed, and one had three conditions diagnosed. There were, then, 85 cases represented by the 76 persons with previously unknown heart disease or hypertension. Twenty-nine (34 per cent) of these cases were hypertensive heart disease, 27 (32 per cent) were hypertension, 21 (25 per cent) were arteriosclerotic heart disease, three were rheumatic heart disease, one was syphilitic heart disease, and four were considered heart disease of unknown etiology.

It would be expected that the screening tests would be somewhat less sensitive in the identification of persons with previously unknown disease than in the detection of all persons with heart disease or hypertension. This is borne out in Table VII. While the total battery of tests was capable of detecting 96.6 per cent of the total persons with heart disease or hypertension, it detected only 92.1 per cent of the persons who were previously unknown. Chest x-ray lost the greatest amount of sensitivity when previously unknown disease is considered separately, dropping from 47.6 per cent to 34.2 per cent. Blood pressure and history were least affected.

TABLE VII. SENSITIVITY OF INDIVIDUAL SCREENING TESTS IN DETECTING PREVIOUSLY KNOWN AND PREVIOUSLY UNKNOWN HEART DISEASE AND/OR HYPERTENSION

TEST	ALL PERSONS WITH HEART DISEASE AND/OR HYPERTENSION			PREVIOUSLY KNOWN			PREVIOUSLY UNKNOWN		
	TOTAL PERSONS	DETECTED BY TEST	% DETECTED BY TEST	TOTAL PERSONS	DETECTED BY TEST	% DETECTED BY TEST	TOTAL PERSONS	DETECTED BY TEST	% DETECTED BY TEST
Total Battery	233	225	96.6	157	155	98.7	76	70	92.1
Blood pressure	233	201	86.3	157	141	89.8	76	60	78.9
History	233	126	54.1	157	90	57.3	76	36	47.4
ECG	233	118	50.6	157	88	56.1	76	30	39.5
X-ray	233	111	47.6	157	85	54.1	76	26	34.2

DISCUSSION

It is disturbing that in the data presented above the specificity ratings were generally quite poor. The specificity ratings in Table IV, for example, show that when the total battery of tests was used, only 31.9 per cent of the persons without heart disease or hypertension were screened as negative; or, put another way, 68.1 per cent of the persons *without* heart disease or hypertension were screened as positive. Few if any case-finding projects could tolerate such poor specificity. It should be borne in mind, however, that the population to which the tests were applied for validation in this study was a sick population, so that it is likely that the signs or symptoms which caused the screening tests to react positively were in many instances related to the presence of diseases other than those screened for. It is probable that had a more normal population been used better specificity ratings would have been obtained. Certainly the findings reported here should be checked against those for more normal populations. Specificity ratings could have been improved by raising the screening levels for the various tests. If, for example, the blood pressure screening level had been raised from 150/90 to 180/100, specificity would have been increased from 74.0 to 91.0 as is shown on Table VIII. This would, however, have resulted in a decrease in sensitivity from 86.3 to 61.4.

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TABLE VIII. SENSITIVITY AND SPECIFICITY OF BLOOD PRESSURE AT VARIOUS SCREENING LEVELS IN IDENTIFYING HEART DISEASE AND/OR HYPERTENSION

SCREENING LEVEL	SCREENEES WITH BLOOD PRESSURE READING AND COMPLETE DIAGNOSIS			DIAGNOSED HEART DISEASE AND/OR HYPERTENSION			DIAGNOSED NEGATIVE FOR HEART DISEASE AND HYPERTENSION		
	TOTAL	POSITIVE ON SCREENING		TOTAL	POSITIVE ON SCREENING		TOTAL	NEGATIVE ON SCREENING	
		NO.	%		NO.	% (SENSITIVITY)		NO.	% (SPECIFICITY)
180/100	690	184	26.7	233	143	61.4	457	416	91.0
160/100	690	217	31.4	233	171	73.4	457	411	89.9
160/96	690	246	35.6	233	181	77.7	457	392	85.8
150/100	690	246	35.6	233	181	77.7	457	392	85.8
150/96	690	269	39.0	233	188	80.7	457	376	82.3
160/90	690	306	44.3	233	198	85.0	457	349	76.4
150/90	690	320	46.4	233	201	86.3	457	338	74.0
140/90	690	342	49.6	233	211	90.6	457	326	71.3

The sensitivity ratings attained by the various screening tests and combinations of tests probably more nearly approximate those that would be attained in screening projects of apparently healthy populations than did the specificity ratings although, again, these should be verified particularly in view of the fact that the population studied was largely Negro. It is particularly encouraging to note that chest x-rays, which are used extensively in this country in tuberculosis case-finding programs, might pick up as much as a third of the previously undetected heart disease and hypertension in the population screened. Cer-

tainly the potential of this already well-established screening procedure should be more fully investigated for heart disease control programs.

SUMMARY

1. The validity of four commonly used screening tests—blood pressure, chest x-ray, electrocardiogram, and history—was determined for each test and for combinations of tests in sorting out heart disease and hypertension from among 690 medically indigent predominantly Negro, outpatients of a large general hospital. To do this, screening tests were administered, and subsequently all screenees were given a complete cardiovascular examination by a diagnostic facility which had no knowledge of the screening test results.

2. The validity of the screening tests is expressed in terms of the percentage of the examinees with heart disease and/or hypertension so identified by the tests (sensitivity), and the percentage of the examinees without heart disease or hypertension so identified by the tests (specificity).

3. Blood pressure proved to be the most sensitive screening test. Other tests did not differ much in sensitivity but varied widely in specificity.

4. Where a screenee who is positive to any test is considered positive, blood pressure and chest x-ray appeared to be the best combination of two screening tests while blood pressure, chest x-ray, and electrocardiogram appeared to be the best combination of three tests.

5. The percentage of previously unknown heart disease or hypertension (sensitivity) detected by individual tests ranged from 34 per cent for chest x-ray to 78 per cent for blood pressure.

6. In general, specificity ratings for the various tests were quite poor.

The contributions of Dr. Joseph F. Fazekas, Chief of Staff of the D.C. General Hospital and his staff, Dr. M. E. Kent who served as Medical Officer-in-Charge of this project, and Mrs. Eloise Worden, Records Consultant from the Division of Chronic Disease and Tuberculosis, U. S. Public Health Service, who assisted in the tabulations, are gratefully acknowledged.

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SCREENING FOR THE HEART DISEASES

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GENERAL CONSIDERATIONS

A GENERAL discussion of screening for heart disease hardly belongs in the same category with a description of precise techniques for the early detection of anemia, cervical cancer, or diabetes. We might begin by emphasizing that the problem is one of screening for the heart *diseases*. Much confusion has resulted because a technique which has been found useful in the screening of one form of heart disease has little use in the early detection of another. Moreover, our present categories of heart disease themselves lack precision. Only in the case of rheumatic and syphilitic heart disease have the etiology and diagnostic categories been well established, and these forms of cardiac disease are now decreasing rapidly in the face of modern control programs.

This review concerns itself solely with the major cardiac illnesses of adult life—coronary heart disease and hypertension.

The definitions of coronary disease and hypertension have already been reviewed,[1] but it is essential to emphasize the gaps in knowledge which can lead to looseness of definition. Do 40 per cent of our adult male population have coronary heart disease? Blumgart[2] found this proportion at autopsy with major coronary arteries occluded by atherosclerosis. Many of these persons suffered no cardiac symptoms and presumably died of other causes. Or should we lower our threshold of diagnosis even further and follow Enos, Holmes, and Beyer,[3] who found that over 75 per cent of a group of young soldiers killed in combat were found at autopsy to have pathologic lesions of the coronary arteries? Perhaps we should agree with Morris[4] that it is not the lesion in the coronary artery but some other factor which is the important feature of the disease. Dedichen and his associates[5] have suggested that this might be an alteration in the clotting of the blood, possibly of dietary origin, leading to both coronary insufficiency and occlusion. Finally, we might leave these experimental speculations and limit the diagnosis of heart disease to those patients who show such actual symptoms as chest pain and signs of cardiac impairment by the electrocardiogram, sphygmomanometry, ballistocardiogram, or x-ray.

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It is this latter category to which we refer when we speak of the early diagnosis of the adult heart diseases. A thorough knowledge of the pathogenesis of these illnesses will probably indicate that they are late stages of the disease processes. Moreover, we have reasoned circularly for we have ended by defining the diseases we are to detect largely by our means of detecting them. This suggests that we must improve the validity and reliability of detection instruments, increase their number, learn how the patients selected by one test differ from those screened by another, and note how the test results change as adults undergo the aging process. As we learn this, we will actually be learning more in regard to heart disease itself. Screening for cardiac illness is thus not merely a means of finding more patients with early disease; it is an important method of supplying basic knowledge about the various forms of the disease in this vital organ.

HISTORY

The characteristic pain of angina pectoris has been well described by Sampson.[6] Although no single criterion of chest pain is pathonomonic of angina, Master[7] found that when three or more of six characteristics of cardiac or noncardiac pain are present a differentiation can be made.

Interviews and questionnaires have been devised to elicit a story of characteristic pain from participants in detection programs. Phillips, Chapman, and Goerke[8] found that three simple questions, dealing with chest pain, fatigue, and dyspnea, gave 50 per cent true positives and only 18 per cent false positives. Kurlander, Hill, and Enterline[9] found that the history gave a sensitivity rating (ability to detect heart disease) of 54 per cent and a specificity rating (ability to detect normality) of 58 per cent (42 per cent false positives). When physicians took the histories there was greater sensitivity than when clerks conducted the interviews, but false positives were still frequent.

The Albany Study[10] discovered that three-fourths of patients later found to have coronary heart disease admitted to "pain, heaviness or discomfort in the chest," but this was also true of about one-fourth of patients whose most significant disease was hemorrhoids. Nevertheless, one-third of the patients finally diagnosed as having coronary disease were found by the use of the history alone, all other tests being negative. No specific questions were of value in the detection of hypertension with or without heart disease.

We may conclude that (a) a carefully elicited history is a good means of detecting coronary heart disease, (b) when certain brief screening questions are used the result is somewhat less productive but still effective, and (c) the history is often the only screening test which is productive. However, the large number of false positives indicates that the history alone is not of sufficient value as a means of reducing the number of middle-aged men who should undergo more detailed cardiologic study.

Of immediate practical value for detection programs is the work of Cochrane, Chapman, and Oldham,[11] adapted by the Albany Study,[10] which indicates the lack of reliability which exists in the taking of histories. More

effort must be made to standardize certain key questions in the history. Each interviewer should be capable of eliciting the same historical data from a given subject if such questionnaires or interviews are to be used as a form of screening.

A strongly positive family history has been found to be of diagnostic value with cases of coronary heart disease but not of hypertension. The Albany Study[10] revealed that twice as many patients with coronary disease had a positive paternal and maternal history of "heart disease" than those patients with hypertension, rheumatic fever, hemorrhoids, hypertensive heart disease, or no obvious significant clinical disease. Hence, this study suggests that the family history may be a useful adjunct to a cardiac detection program, but it also gave about 20 to 25 per cent false positives.

ELECTROCARDIOGRAPHY

The resting 12- or 13-lead electrocardiogram detected 65 per cent of all heart disease found in the Los Angeles Study[8] but also gave 13 per cent false positives. Dawber and co-workers[12] found that the resting 12-lead electrocardiogram gave only about 10 per cent false positives while the use of Lead I alone doubled this figure. False negative results with the 12-lead test were 53 per cent and were approximately the same with Lead I. Dawber concluded that Lead I alone is about as useful as the more tedious 12-lead procedure, but the large number of false negatives with both procedures is disconcerting.

Kurlander and associates[9] found that the resting electrocardiogram detected 71.2 per cent of those with arteriosclerotic heart disease and 55.8 per cent of those with hypertensive heart disease. He also noted that the electrocardiogram gave 23.4 per cent false positives. The electrocardiogram, according to Levine,[13] is extremely accurate in the diagnosis of acute myocardial infarction but leaves much to be desired in the detection of old infarcts, especially small multiple ones. The Albany Study[10] found that of the first 44 cases of coronary heart disease uncovered, roughly one-third were detected by the history alone, one-third by the electrocardiogram plus history, and one-third by the electrocardiogram alone. The electrocardiogram tracings were thus positive in 66 per cent of cases, but this figure would have been reduced to 50 per cent if only the 12-lead resting electrocardiogram had been employed. The additional 16 per cent were detected only after a physical exercise test had been performed and this in turn followed by another 12-lead electrocardiogram. From the standpoint of the electrocardiogram as a detection device, the exercise was crucial in nearly 25 per cent of the electrocardiograms which indicated the presence of coronary disease.

False positives in the exercise test have been reported between 6 and 8 per cent by Master and his co-workers[14] and as high as 22.8 per cent by others[15] who state that they employed Master's criteria. Master also believes that false positives are caused by transient anxiety states and that the electrocardiogram, in such cases, can be rendered normal by the use of ergotamine tartrate or dihydroergocornine.[16] He reports that false negatives are extremely rare, but others[15,17] maintain that with coronary insufficiency or remote myocardial infarctions the percentage of false negatives may be quite high; as great as 43.3

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per cent in one series using the single Master's test. Recently, Mattingly and associates[18] pointed out the great prognostic value of the Master's test when only the ST depression was taken as an indication of a positive finding, even though this depression was slight.

The use of a meal followed in 20 to 60 minutes by an electrocardiogram has been suggested as a test of cardiac function in patients with angina. According to Simonson and McKinlay,[19] this test can be so standardized as to give 75 per cent abnormal responses in cases of proved coronary heart disease and only 2 per cent false positives. It is a safe stress test in its clinical as well as its legal implications, consisting merely of an ordinary meal of about 1,200 calories. The anoxemia test as developed by Levy and his associates[20] is far less likely to give false positives than the Master's exercise test (0 to 3 per cent in two studies), but it is technically rather elaborate for use in screening and gives more than 50 per cent false negatives.[14,21]

It may be concluded that stress due to a meal, physical exercise, or anoxemia, followed by an electrocardiogram, constitutes aid to the screening of adults for coronary heart disease. The anoxemia test, if positive, is highly significant, but a negative test does not exclude the presence of coronary disease. The double two-step and treadmill tests are useful in detecting coronary heart disease, but false positives occur to an appreciable degree, and only further study will confirm whether these positives are truly an early stage of coronary disease. Master's work with the ergotamine drugs as significant in the reduction of false positives, appears not to have found its way yet into mass detection programs.

BALLISTOCARDIOGRAPHY

Although the ballistocardiogram still ranks far behind the electrocardiogram in the diagnosis of heart disease, there are some encouraging reports of its use under certain conditions. The chief difficulty lies in the high proportion of false positives which increase sharply after age 50. In the age group 50 to 59 about 50 per cent of normals give a normal ballistocardiogram, but, by age 70 virtually no clearly normal tracings can be obtained.[22] Below age 50, it gives an appreciable number of false negatives. The ballistocardiogram also tends to become abnormal after exercise or smoking, and after such stress it gives a greater preponderance of abnormal tracings among cases of coronary heart disease. In fact, the ballistocardiogram taken after the smoking of one cigarette gave an abnormal tracing 9 times as often among patients with angina pectoris or remote myocardial infarction than among apparent normals.[15] This is contrasted with a mere 2 to 1 ratio when the electrocardiographic Master's test was used.

Brown, Rinzler, and Benton[23] noted that a normal ballistocardiogram is a good indication that a cardiac patient has made a significant functional recovery. They suggest the use of this instrument in persons under age 50 in order to detect those cardiac patients who possess the functional capacity to return to gainful employment.

Hence, the ballistocardiogram, though still primarily an experimental tool, may be of some limited use for cardiac detection. It has its greatest value in persons under age 50 when it is positive and in persons over age 60 when it is negative.[17]

SIZE AND SHAPE OF THE HEART

The detection of heart disease by the examination of the cardiac silhouette on chest x-ray has been a by-product of mass tuberculosis surveys for some time. Rutstein, Williamson, and Moore[24] demonstrated the dimensions of the problem and some of the practical results obtainable. Putting their data in terms of rates per 1,000, their findings were as follows when 70 mm. chest x-rays are read by cardiologists: (a) 35 are screened as positive for abnormalities of the cardiac silhouette; (b) 27 of these 35 will return for follow-up study; (c) of these 27, 11 will be found normal on follow-up and are false positives; (d) hence, 16 will be confirmed as positive; (e) 9 of these 16 persons are not aware of their condition; and (f) 4 of these 9 should benefit by receiving medical attention based upon current scientific knowledge. In addition, Rutstein demonstrated that cardiologists, reading specifically for heart changes, were able to find 3 times as many cardiac abnormalities as those chest physicians who usually read survey films for tuberculosis.

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If emphasis is placed upon the chest x-ray as a means of detecting unknown heart disease, data gleaned from recent studies indicate a yield of between 5 to 18 such cases per 1,000 persons examined. One study[25] reported a confirmation rate of 80 per cent on follow-up, but Kurlander and co-workers,[8] who gave the 70 mm. x-ray a sensitivity rating of only 56 per cent, found 10 per cent false positives. They discovered that the 35 mm. film was less sensitive, but more specific, giving only 4 per cent false positives.

The assessment of cardiac enlargement by physical examination is known to be poor. The Albany Study,[10] for example, indicated that of 1,453 consecutive examinations on a population of middle-aged male civil service workers, 179 had enlarged hearts on physical examination but only 15 of these were found enlarged on an x-ray study made the same day. Similarly, of the 51 patients with cardiac enlargement on x-ray, 36 were not detected by physical examination.

The relative value of roentgenology in the detection of different heart diseases is presented by Phillips, Chapman, and Goerke,[8] who compared the techniques which contributed to the discovery of cardiac abnormalities among their civil service population. Fluoroscopy was positive in 67 per cent of cases of hypertensive heart disease but in only 9 per cent of patients with arteriosclerotic heart disease. On the other hand, the history was contributory in 52 per cent of cases of hypertensive heart disease and 94 per cent of coronary patients. Sodeman[26] reports, "Results clearly showed that the x-ray examination, although important in the recognition of heart disease, is likely to miss early disease and to be positive chiefly in advanced cases showing remarkable changes in cardiac contour and size." Kleinfield and Redish[27] indicate that the course

of essential hypertension cannot be foretold by cardiac size at any particular time. They could not relate the duration or degree of high blood pressure to the cardiac dimensions.

We may conclude that mass survey x-ray programs are useful in the detection of some forms of heart disease but not others. The proportion of general population groups falsely screened as positive is small enough to permit follow-up of all suspects as a practical procedure.

The use of the electrocardiogram has been suggested as a screening technique for ventricular hypertrophy. Gubner and Ungerleider[28] have described the ECG criteria for left ventricular hypertrophy as left axis deviation in association with an increase in QRS amplitude, ST depression in Lead I, or various abnormalities of T_1.

The Albany Study[10] found that although the electrocardiogram detects more large hearts among those enlarged by x-ray, and vice versa, the two techniques did not screen the same patients and must show either different stages or different kinds of cardiac enlargement. The same study also compared the results when four cardiologists independently read a set of 163 selected tracings. The electrocardiograms of 88 patients were called positive for ventricular hypertrophy by at least one reader. However, the four agreed on only about 25 per cent of the total, three agreed on 18, two on 20, and 27 others were called positive by only one reader. Assuredly much more standardization must be achieved before the electrocardiogram can be recommended as a useful screening device for ventricular hypertrophy.

HYPERTENSION AND SPHYGMOMANOMETRY

The use of a blood pressure reading seems like a simple and accurate means of detecting hypertension. The problem, however, has resolved itself into a series of further questions which probe deeply into the limited knowledge we possess about this disease.

1. Can blood pressure be measured accurately enough by the sphygmomanometer? There is evidence that an obese arm adds a factor of error to the cuff method, giving higher than normal values up to 10 to 15 mm. Hg.[29] Despite this, and certain different criteria for ascertaining the diastolic level, sphygmomanometry has been checked frequently enough with direct intra-arterial readings to lead us to accept it as one of our most accurate cardiovascular determinations for practical use.

2. What is the significance and prognostic value of a single or a few high readings, which may be due to lability of the physiologic cardiovascular control mechanisms? Here opinions differ, but most seem to agree with Levy and his associates[30] that a labile blood pressure and/or tachycardia are significant symptoms which indicate that the patient has an appreciably higher risk of developing permanent hypertension. If either transient hypertension or tachycardia was present, the risk was 3.4 times greater than if both were absent; if both occurred in the same patient, the risk rose to 7.5 times. Hence, it seems worth screening such individuals since they are presumed to be in an early stage of

hypertensive disease. However, Thomson's[31] long-term study of employees at the Metropolitan Life Insurance Company indicated that those having occasional high blood pressure readings did not have a higher risk of developing permanent hypertension in later years.

3. What are the true limits of hypertension and should they be increased with age? Applying the usual limits of 150/90, Master, Marks, and Dack[32] found that 41 per cent of the male and 51 per cent of the female population over age 40 would be labeled hypertensive, and by age 60 this rate would become 60 per cent in males and 70 per cent among females. Deeming such an endemic disease level too high for the practical physician trained to regard hypertension with respect, they have set down new limits.[33] These are based upon the blood pressure range within which readings taken on 80 per cent of the population of a given age-sex group would fall. A borderline classification is recognized which is placed between these normal levels and that greater blood pressure range which would include 95 per cent of the population. Those either over or under the 95 per cent limits are labeled as definitely hypotensive or hypertensive, respectively. Master's table may well be of value in the diagnosis of the "disease" hypertension, but the search continues for techniques for the early detection of the disease by screening the "prehypertensive" patient.

4. Can we screen for other conditions which are indicative of the prehypertensive state? Harris and his associates[34] state that such persons can be detected by a psychologic evaluation under stress. They worked with young college women, obtaining suggestive psychologic results with those who had an original blood pressure of greater than 140/90. Bruce and Thomas[35] used the Rorschach test in medical students and found some evidence that aggression-hostility, obsessive-compulsive trends, and feelings of inadequacy were more prominent among subjects with a positive family history of cardiovascular disease. Such a positive family history was taken as evidence of a prehypertensive, precoronary disease state, but it will probably require a long-term study to prove their contention correct.

Hypertension has long been known to be more frequent among the obese. In addition to the use of standard tables of height and weight for the screening of the obese, the measurement of skin-fold thickness has been in use for some years. James and Hilleboe[10] reported that there are approximately twice as many hypertensives among the obese in each age group, whether the obese state is diagnosed by 20 per cent overweight or by a mid-costo-iliac skin-fold thickness of over 22.5 mm. When both of these tests are positive, the resultant group screened contains 3½ times more persons with diastolic blood pressure over 100 mm. Hg than groups which were negative to both of them. Although such techniques do effect an improvement in specificity by reducing the false positives to about 11 per cent, they still screen only a third of those with an elevated blood pressure.

DISCUSSION AND SUMMARY

Each technique for screening cardiac illness should be considered in terms of its validity and reliability for the detection of each individual variety of heart

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disease. Since diagnostic classifications in cardiology are still relatively crude, the detection tests themselves appear to suggest certain categories. It might be useful, for example, to consider a heart enlarged on x-ray but not showing electrocardiographic evidence of ventricular hypertrophy as belonging to a different diagnostic group from one positive to both tests. Studies of heart disease detection might do well to include more tabulations of findings in such subcategories instead of limiting their analyses to the validity of each individual test in the detection of heart disease as a whole.

While much attention in the literature has been given to the validity of cardiac detection tests (i.e., the minimization of false negatives and false positives), less concern has been expressed about the reliability of each testing procedure. To be useful, each technique should give similar results on repetition by the same or different examiners. Problems in reliability should be further explored in the use of such standard detection techniques as the history, physical examination, electrocardiogram, x-ray, sphygmomanometry, and for any new test which is developed. Long-term studies in cardiac detection should report their findings in a standardized manner. Detection in heart disease cannot remain solely a matter for highly individualized skill, special knack, or elaborate costly apparatus if it is to become useful as a first step in the widespread application of therapeutic knowledge to this extensive disease.

Among the techniques which are available for heart disease detection, the private physician will be particularly interested in those giving a low yield of false negatives. His chief purpose in office diagnosis is the complete evaluation of his patient's illness; his chief fear is failure to detect the presence of disease. Overdiagnosis does not disturb him greatly since false positives can be followed until a definitive diagnosis is made. Hence (a) sphygmomanometry, (b) large size chest x-ray, (c) the double Master's exercise ECG test using the ergotamine drugs as needed, and (d) a careful history will be of the greatest interest to him. The health officer, on the other hand, knowing that he can never discover all of the cardiac disease in his "patient" (the community), is not so concerned about false negatives. But he is seeking easily applied, speedy techniques which give a low yield of false positives. He cannot operate detection programs which will routinely require much expensive and elaborate follow-up. Among the detection devices available, he will be more interested in considering (a) the small-sized mass survey chest x-ray for cardiac size and shape, (b) the assessment of obesity, (c) the single-lead resting electrocardiogram, and (d) possibly the meal ECG test of Simonson. However, for many years to come, all physicians should be interested in further improvement and standardization of each existing detection test and of any new ones suggested by current experimentation. Special attention should be paid to any productive leads in the screening of preclinical heart disease, in the hope that new developments will result in the application of therapeutic regimens which can best impede the further development of the disease.

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SCREENING FOR CANCER

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INTRODUCTION

SCREENING for cancer is considered here as referring to methods for searching the population generally, or segments at major risk, for asymptomatic disease. The attempt to substitute diagnosis at an asymptomatic for the symptomatic stage (symptomatic is used here to include both objective and subjective evidence of disease) implies repetitive use of the screening procedure in the same population at some periodic time interval. Ideally, this interval would be the time between the point when the screening procedure can first recognize minimal cases of the disease and when these cases of the disease are at the stage of metastatic spread. Screening procedures for cancer, for obvious reasons, have more potential value in reference to those sites of cancer that cannot be inspected or palpated by the individual.

The concept of screening population for asymptomatic disease has certain special implications in relation to cancer. Among the so-called chronic diseases, cancer is one of the most acute and lethal. As evidence of this, we find cancer as the second leading cause of death, but do not find it listed among the most important causes of disability either in terms of individual cases or for all cases of disease collectively. Cancer, then, has the "kill or cure" dichotomy usually associated with many acute infectious processes. For most types of cancer this dichotomy arises at that point in time when metastasis takes place. This point in time all too frequently antedates symptoms (unfortunately we do not know to what extent), at least for those tissue sites not visible or palpable to the victim. If we are to make any sizable shift from kill to cure category with present therapeutic methods for patients having cancers inaccessible to their own observation or palpation, asymptomatic diagnoses must be made and at a time prior to metastatic spread.

It is well to keep in mind that curative cancer therapy at present involves locating, delimiting, and totally destroying cancer tissue. While it is of more theoretical than actual importance at the moment, a screening procedure should

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not be more sensitive than clinical ability to locate and identify the disease. For example, if a beginning carcinoma in situ, wherever it might occur, were accompanied by a measurable and relatively specific constitutional change, it might often impose an overwhelming task for clinical management in locating the site of the disease. The psychologic implication of labeling an individual as having a lethal disease that cannot be found requires little imagination. If and when chemotherapy becomes a curative modality, some basis for cancer diagnosis other than morphology may assume practical importance.

SCREENING FOR CANCER GENERALLY

Except for sex, a few ethnic proclivities for cancer of certain sites, and a few environmental and industrial exposures, age provides the only practical basis for selecting high and low cancer risk segments of the population. In the interest of economy and efficiency, then, searching for asymptomatic cancer in all tissue sites where it might occur should be concentrated in the older segment of the population where cancer risk is largely centered. There are two possibilities for accomplishing this: (1) direct or indirect examination by clinical means of all tissue sites commonly affected with cancer; or (2) identifying individuals harboring an asymptomatic but clinically recognizable cancer by some test procedure, and then locating and identifying the cancers in these preselected individuals by the method outlined in (1).

The second method can be readily disposed of by saying that at present none of the general tests proposed for cancer have been established as suitable for case finding of asymptomatic disease. The urgent need for such a test procedure has led to a continuing search for more discriminatory methods. A handicap to developments in this field is the paucity of demonstrable qualitative changes in cancer tissue or the host organism. A number of reviews of this field of work are available.[1-4] Also, a methodology for evaluation and performance criteria proposed for cancer tests,[5] and the results of systematic evaluations of several procedures have been published.[6]

The first method of cancer case finding, the clinical searching of asymptomatic persons for evidence of disease, is a special application of the laudable and time-honored admonition that everyone should have an annual physical examination for health maintenance. This concept became formalized and implemented in Cancer Detection Centers. Such centers developed widely over the country and a system of inspection and approval was established and administered by the American College of Surgeons. The Centers varied as to the content of the examination and the degree to which the clientele were limited to asymptomatic persons. They all had two serious defects in so far as general population screening for unsuspected cancer is concerned. They were too limited in volume of patients served, and too expensive per examinee.

Although studies have been made by periodic examination of volunteer closed populations,[7] the concept of periodic screening of the same general population for cancer of all common sites by physical examination methods has yet to be properly evaluated. Only then will it be possible to determine whether a

population so served actually has an improved cancer experience over a population not subjected to such an organized attempt at cancer case finding. There are reports on the cancer yield of examining asymptomatic persons in a well-run Center,[8] and on the efficiency of such a screening procedure in terms of future cancer experience of examinees.[9,10] Cancer Detection Centers perhaps have served their greatest usefulness as an educational medium for both physicians and patients as to what constitutes an adequate and thorough examination for cancer.

There seems to be a general feeling now that Cancer Detection Centers are not the answer to general population case finding. The function is again being returned to the private physician's office with the slogan of, "every doctor's office a cancer detection center." Some attempts to promote cancer screening in physicians' offices have been organized through the cooperation of the communities' physicians,[11,12] but it is yet to be shown that this type of service can be provided in adequate amount and be effectively promoted for screening the entire older adult population of a community periodically. How effective it would be in changing the communities' cancer experience is still another question. It would certainly be less effective for some cancer sites than others; for a few special sites it might be quite effective.

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SCREENING FOR CANCER OF INDIVIDUAL SITES

For the most part, screening for asymptomatic cancer involves direct or indirect observation of the various tissue sites for gross evidence of disease. This is relatively easily accomplished for those sites usually referred to as accessible since they can be seen or felt without special preparation of the patient and without technically difficult instrumentation. For screening the inaccessible sites, the needs for special instrumentation for direct visualization, or the time required and the cost of indirect visualization by x-ray examination, usually precludes the use of these techniques. There are exceptions to this latter generalization. At least one Cancer Detection Center experience indicates that proctoscopic examination can be efficiently and effectively used as a routine examination procedure.[13] Attempts have been made to use miniature x-ray chest films for discovering unsuspected cancer of the lung. A similar photofluorographic technique has been developed for examining the stomach for evidence of gastric cancer. Stool examinations for occult blood, the demonstration of achlorhydria, and urine examinations for microscopic evidence of hematuria have been used as indicators for selecting individuals to be surveyed by more costly and time-consuming procedures to detect gastrointestinal and urinary tract cancer.

For at least one site of cancer, screening and establishment of a final diagnosis can now be performed without gross evidence of disease. This is the application of exfoliative cytology and confirmatory biopsy to the discovery of cancer of the cervix.

In the following discussion only those sites of cancer will be considered where some special technique is available for screening purposes, other than inspection and palpation. For those sites of cancer that are equally accessible to the

individual as to the examining physician (e.g., skin, lip, breast, and mouth) health education has an equal potential and a considerable less cost than a system of periodic screening. The greatest effort of this kind has been the promotion of breast self-examination by women. An excellent film produced jointly by the National Cancer Institute and the American Cancer Society has been widely shown. A few attempts have been made to evaluate the effectiveness of the film in inculcating the practice of periodic self-examination of the breast among those who have seen the film.[14,15] Indications are that the practice is not uniformly adopted. No doubt, continuous and prolonged educational effort will be necessary to bring about acceptance of breast cancer liability and the motivation for breast self-examination.

Cancer of the Stomach.—This important site of cancer, particularly for men, has had a very poor prognostic record. By the time symptoms occur, the disease has often spread beyond the point of complete surgical removal. Inaccessibility of the site, and the time and cost involved in usual diagnostic procedures for gastric cancer make the development of screening procedures for this site difficult. The principle screening techniques that have been considered include: (1) photofluorographic examination of the stomach; (2) screening for achlorhydria (since this abnormality is frequently associated with gastric cancer); and (3) gastric exfoliative cytology.

Attempts have been made to determine the efficiency of gastric x-ray examination for finding asymptomatic gastric cancer.[16] The yield of gastric cancers discovered was not impressive. Also, conventional x-ray examination of the stomach would be too costly a procedure and too consuming of professional time to be practical for general population screening.

An attempt to make x-ray examination of the stomach a practical screening procedure was made through the development of a photofluorographic method.[17] Small film records of the stomach in several positions could be taken by a technician for later interpretation by the radiologist. The technique has been used for screening and permits asymptomatic lesions to be found.[18] An unexpected complication was the failure to induce some of the individuals with asymptomatic lesions to submit to surgery. The photofluorographic technique has been used as a screening method in a few other localities.[19] It has not been fully evaluated, however, as a means of bringing the gastric cancer cases developing over a period of time in the same population to asymptomatic diagnosis. Until such a study is undertaken, the value of the technique for improving the generally poor prognosis for this important site of cancer cannot be determined.

An attempt has been made to concentrate the gastric cancer cases in the general population by limiting x-ray examination to those with achlorhydria. Recent development of a method for determining gastric acidity indirectly with a cation exchange resin has made this a practical approach.[20] Achlorhydria exists in 20 to 25 per cent of noncancerous older adults[21] and in about 70 per cent of cancer patients.[22] While limiting x-ray examinations to those with achlorhydria would reduce considerably the number to be screened, it would also discard almost a third of gastric cancers to symptomatic diagnosis. It is difficult

to see how introducing this amount of inefficiency can make such an expensive examination method practical for screening purposes.

The diagnostic value of gastric cytology has been investigated by a number of centers. Techniques for recovering representative cell samples by mechanical abrasive methods[23,24] and use of a mucolytic enzyme have been developed.[25] While gastric cytology is of definite value in establishing a diagnosis of a patient suspected of having gastric cancer, the necessity for intubation to get specimens would seem to preclude application of this method to general population screening.

Cancer of the Lung.—Cancer of the lung has aroused a great deal of interest because of its increasing incidence over the past 20 to 30 years. This trend is reaching alarming proportions in males, where it is displacing the stomach as the leading site of cancer occurrence. When cancer of the lung is diagnosed as a result of symptoms, the possibility of curative treatment is extremely poor. Some method of screening for asymptomatic disease, therefore, is urgently needed.

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The only technique immediately at hand for asymptomatic lung cancer case finding is the minature chest x-ray film. An attempt has been made to determine the potentiality of this technique for lung cancer case finding as a by-product of a number of tuberculosis screening surveys.[26-28] The largest of these studies was in Los Angeles in 1950. Guiss has reported on the lung cancer findings of this survey.[29]

If one applies the age-sex specific incidence rates obtained in the 10-city cancer morbidity surveys of 1947-48[30] to the corresponding groups of the Los Angeles survey population, it would be expected that the population 25 to 84 years of age would produce annually 262.4 lung cancer cases among the men and 65.6 cases among the women. The Los Angeles survey found in this population 160 cases of lung cancer among the men and 53 among the women. The ratio of observed/expected lung cancer cases in such a survey gives a rough estimate of the portion of a year that the x-ray screening method can antedate usual diagnosis (symptoms leading to seeking medical advice), 0.6 for men and 0.8 for women. This suggests that x-ray screening would antedate clinical diagnosis by about 7 months for men and 9 to 10 months for women.

It must be remembered that a number of biases undoubtedly operate in the population that selects itself for inclusion in an x-ray survey. Also an initial x-ray survey of a population is finding prevalence of undiagnosed disease and not incidence. The slow-growing lesions with more favorable therapeutic prognosis will constitute, therefore, a disproportionately large component of the cases found. The estimates of the efficiency of x-ray screening for lung cancer just given, therefore, are subject to several sources of error. Guiss' data indicate that the 3-year salvage of the cases found in the x-ray survey is an improvement over usual experience with lung cancer treatment. Others who have studied this technique for its potentialities for improving the results of lung cancer treatment are less encouraged.[31]

The true potentiality of x-ray screening for lung cancer cannot be determined until it has been studied as a repetitive case-finding procedure in the same popu-

lation over a period of time. The promotion and effective application of a continuous screening procedure for lung cancer in the general population would be a sizable and expensive program. The advantages in terms of prognostic improvement should be better established than at present by a properly designed evaluation study before such practical use of the method is attempted.

Sputum cytology has proved itself to be an extremely useful procedure in establishing a diagnosis in a lung cancer suspect. Its disadvantages as a screening procedure is that it requires sputum from a productive cough, and multiple specimens must be examined to be sure one that is representative is obtained.

Cancer of the Uterus.—The most promising development in the cancer screening field has been the method of examining exfoliated cells for evidence of cancer proposed by Papanicolaou[32] and demonstrated as a useful clinical procedure by Papanicolaou and Traut.[33] Although it is a valuable aid in the diagnosis of carcinoma of any site from which the exfoliated cells can be recovered, the female genital tract provides the only technically simple source of specimen material.

The more or less routine use of vaginal cytology in a number of centers has produced findings indicating that there is a prolonged period during which carcinoma of the uterine cervix does not progress beyond being an intraepithelial lesion. This stage of the disease should almost certainly antedate metastasis and therefore be curable. The cytologic method can indicate the presence of cervical carcinoma when it is in this stage, and hence is a powerful weapon for screening purposes. Since the evidence indicates that the intraepithelial or in situ stage of the disease may persist for years, the frequency of screening individual women might effectively be done at intervals greater than a year. A study, now in progress in Memphis, Tennessee, in which the general population of adult women are being offered vaginal cytology as a screening procedure,[34] should answer some of the questions regarding the relationship between carcinoma in situ and invasive cancer of the cervix.[35]

It is hard to conceive of a cancer-screening procedure based on morphology having greater potential value than cervical cytology. Twenty-seven years after the method was proposed[32] and twelve years after its value was demonstrated,[33] its full potential as a means of overcoming mortality from one important site of cancer has still to be realized.

Cancer of the Prostate.—One of the oldest laboratory tests that has proved to be clinically useful in the cancer field is the increased serum acid phosphatase associated with prostatic cancer. Since elevations of this enzyme are associated with the metastatic spread of prostatic cancer, however, it had no value as a case-finding method. Recently, Fishman[36] has developed a method using a substrate that distinguishes the serum acid phosphatase of prostatic origin. It has been found that this fraction of the serum acid phosphatase is elevated in the presence of prostatic cancer when the lesion is still confined to the prostate.[37] This test procedure is under study in a number of laboratories and may provide a screening method for this important site of cancer in men.

Cytologic examination of prostatic fluid has also been studied as a means of diagnosing prostatic cancer. It has proved to be very useful as a clinical aid

to diagnosis of patients under suspicion.[38] Its usefulness for case finding of prostatic cancer in asymptomatic men has not been adequately evaluated. Combining the prostatic serum acid phosphatase determination with the cytologic study of prostatic fluid is under investigation.[39]

Cancer of the Lower Gastrointestinal Tract.—The cytologic method is of value in the diagnosis of cancer of the large intestine but the special procedures required for obtaining proper specimens preclude application as a case-finding procedure. Stool examination for occult blood has been used to some extent for case finding, but has never been properly evaluated. Its dependence on an ulcerating lesion makes it seem unlikely that this has great promise as a useful method for finding anatomically early cancer.

Urinary Tract Cancer.—Cytology and microscopic hematuria are methods that might appear to have screening potential in cancers of these organs. The difficulties involved in handling urine specimens for cytologic examination and microscopic hematuria militate against these as a screening procedure.

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DISCUSSION

It is not the purpose of this presentation to deal with the philosophical considerations of screening procedures for identifying unsuspected disease in the general population. In the cancer field, however, there has been no objection to encouraging enlightened self-detection by popularizing the signs and symptoms that suggest the possibility of cancer and should bring the individual to seek prompt medical advice. Providing this same individual with a laboratory or x-ray finding, which suggests the likelihood of disease as a basis for seeking medical advice while he still is free of symptoms, does not seem out of harmony with this concept.

What is more important is the apparent lack of clear understanding as to the guiding principles that identify a screening procedure and the failure to realize that a screening procedure can and should be subjected to scientific evaluation. Only thus can its performance as a screening procedure be known and the advantages accruing from its use reasonably estimated.

Some of the guiding principles that identify a cancer-screening procedure are:

1. The screening procedure must be able to improve the prognosis of the cancer cases it detects. Presymptomatic is not necessarily synonymous with premetastatic. A case-finding technique does not necessarily become a screening procedure by virtue of the fact that it is the best we have to offer.

2. A screening procedure has as its purpose the substitution of asymptomatic for symptomatic diagnosis. It is therefore directed toward the general population and must be promoted and maintained as a continuous and repetitive processing of that portion of the general population at major risk. If it is to be more than a haphazard gesture, it must be organized and promoted in a positive manner, not limited to those who perchance fall under medical surveillance for an extraneous reason.

3. A screening procedure for cancer must identify a few individuals with cancer from a large population in which the disease is not present. It is expected

to do this efficiently and economically since it must be carried out continuously and repetitively. Its desirable attributes, then, are technical simplicity and accuracy. The ideal in terms of personnel would be to eliminate the definitely noncancerous at the technician level and to identify the cancer among those under suspicion at the professional level.

In an attempt to express the efficiency of a cancer case-finding method it has become common practice to indicate this in terms of the cost of finding a case of cancer. This is meaningless if not a little repugnant.

The expected annual cancer yield of a known population can be reasonably determined from available cancer age-sex specific incidence rates.[40] Since a screening procedure attempts to identify this yield in an asymptomatic stage of development, it is possible to make a rough estimate of the sensitivity of a screening procedure from the results of an initial screening (and from this estimate the cyclic frequency for its effective repetition). Repetitive screening, thereafter, will produce cancer cases as some multiple of the expected incidence. For example, if repeated annually this would equal the expected annual incidence, reduced by the inherent error of the technique, and further reduced by some proportion of all incident cases that progress from earliest screening evidence of disease to symptoms in less than a year. The cost of a screening procedure then, is the unit cost of applying the procedure multiplied by the size of the population subjected to screening. The decision as to whether it is worth while depends on determination of the prognostic advantage of cases so identified as compared to patients diagnosed on the basis of symptoms. This is a time-consuming problem and, at least in the cancer field, can only be determined by a carefully designed study, for reasons which follow.

The initial use of a screening procedure in a population identifies those cases of the disease being sought in all stages of development from the earliest changes that the screening procedure can identify up to the point of symptoms that normally lead to diagnosis. The initial application of a screening procedure yields cases that represent the prevalence of undiagnosed disease in the stages the screening procedure can detect. The ratio of prevalent screened cases: expected annual incidence provides a rough estimate of the *average* time in years that the screening procedure can antedate clinical diagnosis.

This estimate is subject to two sources of bias. If the screened sample is self-selected from the population, those with beginning symptoms of their disease may be attracted to or avoid inclusion in the screened group. A second and unavoidable bias is the fact that slower progressing disease accumulates disproportionately among prevalent cases as compared to incident cases. For example, let us assume for a specific cancer site (the lung, for example) that cases occur annually at an equal rate that could have been found by a screening method six months, one year, and two years before becoming symptomatic. These three growth-rate types are occurring in the ratio 1:1:1. An initial screening procedure would find these cases in the ratio of 1:2:4. The ratio of observed/expected cases, then, would overestimate the average efficiency of the screening procedure in antedating usual diagnosis.

The bias of disproportionate accumulation of slowly progressing disease is of more serious concern in considering prognostic advantage of cases identified in an initial screening. Continuing with the example just given, presume the 5-year survival of these three chronology types is 0, 5, and 20 per cent, for an over-all average of 8.7 per cent. The initially-screened cases would have a 5-year survival of almost 13 per cent—an apparent but fictitious advantage. Prognostic advantage for cases found by a screening procedure, to be compared with those diagnosed symptomatically, then, must be determined on the cases found in the rescreenings of the same population.

As examples of the power of screening procedures to accomplish their purpose, x-ray screening for lung cancer and cytologic screening for cervical cancer offer extremes. X-ray screening finds less than the expected annual incidence of lung cancer cases; and cytology, whenever applied routinely, has always found several times as many cervical cancers among asymptomatic women as the expected annual incidence of clinical cancer.

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The fallacy of measuring efficiency of a screening procedure by cost per case of cancer found is well illustrated by cervical cytology. Initial screening produces a high yield of cases, because the cytology method can identify the accumulation of lesions in all stages from carcinoma in situ up to clinically evident and symptomatic invasive cancer, and therefore at a low cost per case found. Not all of these, the anatomically more advanced being the exception, will benefit from being found asymptomatically. Rescreening will produce a low yield of cases—incidence of whatever the earliest stage of carcinoma of the cervix is (presumably carcinoma in situ)—at a high cost per case found. However, it is a reasonable prediction that most if not all these latter cases would benefit prognostically from being found at this early stage. The unit cost per screening procedure will be approximately the same for initial screening and rescreening, but the cost per case found will be low in the former and high in the latter.

SUMMARY AND CONCLUSIONS

Symptomatic cancer is all too frequently not curable with present therapeutic methods. This had led to attempts to recognize the disease in asymptomatic individuals. Efforts to accomplish this have largely centered on searching for demonstrable lesions by clinical means. A formalized effort to implement this concept resulted in the development of Cancer Detection Centers. Inadequate capacity and high cost per examinee has made this approach impractical and clinical screening for cancer is again being considered the function of private physicians. The feasibility of promoting and sustaining such a program on a continuing basis, and the prognostic improvement that might result is still to be demonstrated.

Many laboratory tests for cancer of all sites have been proposed. None has yet been acceptable for screening purposes. A number of screening procedures for cancer of particular sites are being studied. Most are in need of further evaluation to determine their value in terms of improving the longitudinal cancer experience of a general population benefited by repetitive screening with the procedure.

The most promising screening procedure for cancer of a particular site is the use of the cytologic examination for cervical cancer. All the evidence points to the potentiality of this method to render cancer of this important site for women a curable disease. In spite of the many years this method has been known, its potentiality is still to be realized. If this screening method fails to fulfill its potentiality, there appears to be little hope for prognostic improvement from the use of any of the other screening procedures that have been proposed.

The attributes of a case-finding method to be a screening procedure and the problems of evaluation are discussed.

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THE DETECTION OF GASTRIC CARCINOMA BY PHOTOFLUOROGRAPHY

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IN RECENT years, mass x-ray technique (photofluorography) has been used extensively for the early diagnosis of a variety of diseases. Perhaps the most successful application of this method has been in the early detection of pulmonary tuberculosis. Indeed, it is not improbable that the improvement in the mortality statistics of tuberculosis in recent years may be ascribed, in part, to the extensive use of photofluorography of the chest by the Armed Services, by health agencies, and by general hospitals.

In view of the success of mass x-ray technique in tuberculosis, it is not surprising that considerable thought has been given to its possible application in the early detection of gastric carcinoma. It is well known that this lesion is usually well advanced when symptoms occur, and hence any method which would detect the lesion at an early and asymptomatic stage would be highly attractive from a public health standpoint.

In order to evaluate mass x-ray methods in the early detection of gastric carcinoma, a study [2-4] was undertaken at the Johns Hopkins Hospital, in early 1948, in which photofluorographic gastrointestinal examinations were performed on all new dispensary patients 40 years of age or over. In the subsequent four years, a total of well over ten thousand such examinations was performed.

It was hoped that this experiment would provide answers to the following four questions:

1. Is photofluorography of the stomach a practical procedure from the standpoint of the individual being examined?
2. Is photofluorography of the stomach a practical procedure from a technical standpoint?
3. Is photofluorography of the stomach able to detect a significant number of early gastric carcinomas when these lesions are still asymptomatic?
4. Is photofluorography of the stomach a practical procedure from a professional standpoint?

Favorable replies to all four questions, of course, are essential, if photofluorography is to be a satisfactory tool in the control of cancer of the stomach.

The results of the study indicate that, from the standpoint of the individuals under examination, photofluorography of the stomach is entirely practical. Indeed, photofluorography of the stomach can be carried out almost as simply as photofluorography of the chest. It was found, for example, that it was un-

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necessary for the individual under examination to undress or to be in a fasting state at the time of the examination. In the procedure, each individual was first given 2 ounces of a mixture of barium sulfate, warm water, and chocolate malt, after which an anteroposterior and two right anterior oblique exposures were made. The individual was then asked to drink an additional 4 ounces of the opaque mixture, making 6 ounces in all, and a posteroanterior and two right anterior oblique exposures were made. Thus, each individual received a total of six exposures, all of which were made in the recumbent position. A technician performed the entire examination, which took, at the most, four to five minutes.

This study also indicated that photofluorography of the stomach was entirely practical from a technical standpoint. By means of high-speed Schmidt cameras, photofluorograms of the stomach comparable in detail to conventional roentgenograms were obtained routinely without excessive radiation exposure to the individual under examination. With a single technician, examinations proceeded rapidly and without undue strain upon the x-ray equipment. Technically satisfactory films were obtained on well over 90 per cent of the individuals studied.

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The portion of the study which was designed to evaluate the ability of photofluorography to detect gastric carcinoma at an early and asymptomatic stage produced some rather interesting results. Thirty-three individuals with either absent or extremely minimal gastrointestinal symptoms demonstrated lesions interpreted as early gastric cancer. All had come to the hospital with complaints other than those associated with the gastrointestinal tract. All felt sufficiently well so that it was possible to induce only twelve to submit to abdominal surgery. Of these, five had early gastric carcinoma; two yielded benign gastric polyps; one, a leiomyoma; and one, a neurofibroma. Three others had no lesion and were mistakenly diagnosed as having a pathologic process from deformity of the antrum by extrinsic adhesions or by hypertrophied rugal folds.

Twenty-one of the asymptomatic individuals who presented photofluorographic evidence of a gastric lesion refused surgical operation. All stated that they felt sufficiently well and that they did not wish to undergo a major abdominal operation. We found this reaction interesting, especially in view of the extensive educational program in recent years to inform the population of the dangers of neoplastic disease and of the need for its early diagnosis and removal. Follow-up studies of these twenty-one individuals are now in progress. Further data on them will be presented at a later time.

Although the foregoing results indicate that photofluorography exhibits a tendency toward false positive diagnoses, there is reason to believe that the technique may be useful as a tool in the early diagnosis of gastric cancer. This is further borne out by the fact that, of the more than ten thousand individuals who have been examined, only one has returned to the hospital at a later time with a gastric neoplastic process which was overlooked during his photofluorographic study.

Although the foregoing data are revealing, the greatest revelation of this study came when an answer to the professional practicality of gastric photofluorography was sought. Although the answers to the first three questions of

this study were, in general, favorable, the answer to the fourth question was quite disappointing. The study indicated that approximately one individual in four hundred above the age of 45 presented photofluorographic changes suggestive of gastric cancer. Since each individual required six photofluorographic films for a complete study of the stomach, it is evident that the physicians who interpreted the films were required to go through approximately twenty-four hundred in order to discover each case of unsuspected disease. Such an experience proved to be sufficiently uninteresting and burdensome that at times it exerted a demoralizing effect on almost every physician who took part in the study. Furthermore, when a positive case was found, it did not provoke the same interest as a case of tuberculosis, discovered by photofluorography. Tuberculosis is a communicable disease, and the reader of photofluorographic films knows that he not only is bringing under control the unsuspected case of tuberculosis which he discovers, but also is preventing the occurrence of many other cases. This situation did not prevail for the readers of gastric photofluorograms, and their enthusiasm for the procedure diminished rapidly as the study progressed.

In addition to the discouraging influence of photofluorography on professional morale in the detection of gastric carcinoma, there is another serious problem posed by the technique. In this day, when the professional services of physicians are at a premium and hence in great demand, there is considerable question whether we can afford the luxury of assigning not inconsiderable numbers of physicians to the examination of large population groups for gastric carcinoma by photofluorographic methods. Certainly, the yield of significant lesions is small. This is borne out not only by the report of this study, but also by statistics generally.[1] This same question, of course, may be asked also about other mass screening techniques for neoplastic lesions. However, the question appears particularly cogent in gastric photofluorography, since the necessity of multiple films imposes the expenditure of a great deal of time for every positive case discovered.

In view of the foregoing, it appears that, although mass x-ray methods by photofluorography are entirely practicable from the standpoint of the individual under examination, from the standpoint of the technical procedure, and from the efficacy of the technique in detecting early lesions, the technique is far from satisfactory from the professional viewpoint. Although the procedure yields films of good interpretability, the small number of significant cases in the general population above the age of 45 makes it necessary for the photofluorographic reader to expend much time and energy in the finding of each case. The procedure, therefore, seems unlikely to be worthwhile.

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SCREENING FOR DIABETES

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"FROM every viewpoint—personal, community, economic, and professional—it is urgent that unrecognized diabetes be discovered and medical care instituted." So says an editorial, "Discovering Unsuspected Diabetes," in the *Journal of the American Medical Association*.[1] That these "unrecognized" diabetics constitute a major medical problem in the United States is clear from the fact that there are an estimated million or more persons with unrecognized diabetes.

The awareness of this problem has led many health departments, state as well as local, and many voluntary and private agencies to undertake screening for diabetes. The problems being encountered in these programs are the difficulty of ensuring that suspects report for diagnosis, the establishment of criteria for diagnosis of asymptomatic diabetes, and the standardization of levels of positivity for various screening tests at various hours after eating.

The objectives in the treatment of diabetes as listed by Ricketts[2] are: to relieve symptoms, to achieve and maintain normal nutrition, to preserve whatever is left of the insulin-producing power of the pancreas, and to prevent, postpone, or minimize complications.

Early detection can help us attain all these therapeutic objectives before ravages of the disease have set in. The relief of symptoms and maintenance of nutrition are attained through the judicious use of diet and insulin. With the recent work of Wrenshall, Bogoch, and Ritchie,[3] and Bornstein and Lawrence,[4] it appears that relative or absolute insulin deficiencies play a prime role in diabetes. There is experimental and clinical evidence that the avoidance of strain in the insulin-producing capacity of the pancreas, through early and adequate therapy, will preserve more of the functional tissue.

Early detection can prevent the acute complications of diabetes, namely diabetic acidosis or coma. Although less frequent in recent years, admissions to hospitals of persons in diabetic coma are still too many, and from 1 to 10 per cent of these die while in coma.[5]

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The etiology of vascular complications in diabetes is not known. Ricketts has ably pointed out that the vascular lesions found in experimental diabetes have developed for the most part in animals with hyperglycemia and glycosuria of long duration.[2] While the human evidence is still a subject of debate, it behooves the medical profession to offer the best available therapy which at present points to good control. Early detection provides for the earliest possible initiation of good control.

It is of interest that recently the increasing awareness of the relation of diabetes to vascular complications has led to the more frequent use of diagnostic tests for diabetes in patients with gangrene of the extremities. In this group, large numbers are found to have laboratory evidence of the disorder.

The early detection and control of diabetes during pregnancy certainly will lead to a lessened fetal and maternal mortality. Certain acute infectious diseases in the presence of diabetes of any degree of severity are more susceptible to therapy after the diabetes has been recognized and is under good control. Untreated renal infections, common in those with uncontrolled diabetes, are an important cause of death in diabetics.[6]

There is evidence that diabetic cataracts in experimental animals are related to the severity of hyperglycemia. This suggests that another complication in human diabetes may be preventable by early diagnosis and treatment.[2]

Styron[7] presents data to show that diabetics discovered and treated early have less severe disease, fewer vascular complications, fewer amputations of extremities, and a lower incidence of neuropathy.

FIELD EXPERIENCE WITH DIABETES SCREENING

While screening for diabetes through urine testing is a long established procedure, in recent years blood tests are being used more extensively. Screening activities using urine or blood tests have been carried out by various sponsoring agencies. As an annual activity, the American Diabetes Association sponsors nationwide detection programs to find the estimated million unknown diabetics. Several State Health Departments have conducted state-wide detection programs, and many county and city health departments have undertaken diabetes screening. The United States Public Health Service, in cooperation with local health agencies, has engaged in a few diabetes-detection programs on a demonstration basis.

Screening activities have been characterized by a variety of testing methods, different blood and urine levels considered positive, and various procedures for re-examination and referral. Screening programs have also differed in the composition of the population screened, some including all persons in the community, some just those persons 40 years of age and older, some industrial groups only, and other selected groups. The yield of a detection program is greatly influenced by the existing standards of medical diagnosis, the age and sex distribution of the group, and the basic prevalence of undetected diabetes.

Table I contains a summary of 5 selected screening programs and presents a description of procedures used and results obtained. Information of this type

TABLE I. RESULTS OF SELECTED DIABETES CASE-FINDING PROGRAMS.

LOCATION	Duval and Palm Beach Counties, Florida	State of West Virginia	Bakersfield, Cal.	Dallas, Texas	Milwaukee, Wisconsin
CONDUCTED BY	State Board of Health	State of West Virginia	Kern Co. Health Dept. and State Health Dept.	City Health Dept. and USPHS	City Health Dept. and USPHS
DATES	April 1950-Jan. 1953	July 1, 1952-Dec. 31, 1953	Sept. 24-30, 1951	Feb. 1950-Feb. 1952	Oct. 1949-Oct. 1950
POPULATION	Persons over 16 years of age	Persons reporting to Health Dept. Clinics	Adults visiting county fair	General	Selected community groups
SCREENING METHODS	Capillary blood (Wilkerson-Heftmann)	Venous blood (Wilkerson-Heftmann)	Capillary blood (Wilkerson-Heftmann)	Venous blood (Wilkerson-Heftmann)	Capillary blood (Somogyi-Nelson)
SCREENING LEVEL	130 mg./100 c.c. regardless of food or carbohydrate intake	130 mg./100 c.c. regardless of food or carbohydrate intake	180 mg./100 c.c. regardless of food or carbohydrate intake	130 mg./100 c.c. regardless of food or carbohydrate intake	140 mg./100 c.c. at ½ to 1½ hr. after a full meal
RETEST METHOD	Blood sugar (Somogyi-Nelson) two hours after a meal	Random blood sugar (Somogyi-Nelson)	Not done	Blood sugar or glucose tolerance test (Somogyi-Nelson)	Blood and urine sugar (Somogyi-Nelson) G.T.T. in selected cases
RETEST LEVEL	150 mg./100 c.c. with controlled carbohydrate intake	Interpretation depended upon the time since carbohydrate intake	Not done	Fasting 110 mgm. per cent or more; nonfasting 180 mgm. per cent or more	Two or more postprandial blood sugars above 200 mg./100 c.c. with glycosuria or a diabetic type glucose tolerance curve.
BASIS OF REFERRAL	One or two positive retests	Positive retest	All persons screening positive	Results of retests evaluted, if possibility of diabetes individual referred	All those positive on retests

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TABLE I. RESULTS OF SELECTED DIABETES CASE-FINDING PROGRAMS—(CONTINUED)

	(NO.)	(%)	(NO.)	(%)	(NO.)	(%)	(NO.)	(%)	(NO.)	(%)
NUMBER OF PERSONS SCREENED	12,690	100.0	9,254	100.0	2,160	100.0	58,727	100.0	4,034	100.0
PREVIOUSLY KNOWN DIABETICS	*	*	*	*	29	1.3	386	0.7	0	—
SCREENED POSITIVE	410	3.2	242	2.6	31	1.4	778	1.3	365	9.0
PREVIOUSLY KNOWN DIABETICS	*	*	95	1.0	11	0.5	191	0.3	0	—
PREVIOUSLY UNKNOWN POSITIVES RETESTED	410	3.2	49	0.5	—	—	465	0.8	338	8.4
RETESTED POSITIVE	126	1.0	33	0.4	—	—	271	0.5	113	2.8
REFERRED TO PHYSICIAN FOR DIAGNOSIS	126	1.0	179	1.9	31	1.4	271	0.5	114	2.8
REPORTED ON BY PHYSICIAN	121	1.0	126	1.4	31	1.4	177	0.3	107	2.7
DIABETES DIAGNOSED	95	0.7	120	1.3	20	0.9	136	0.2	80	2.0
PREVIOUSLY KNOWN DIABETICS	12	0.1	77	0.8	11	0.5	0	—	0	—
PREVIOUSLY UNKNOWN DIABETICS	83	0.7	43	0.5	9	0.4	136	0.2	80	2.0

Source: Summary of diabetes screening projects: Department of Health, Education, and Welfare: Public Health Service: Division of Chronic Disease and Tuberculosis.

*Data not available. —Not done.

is available on 50 different screening programs in "A Summary of Some Diabetes Screening Projects," from the Chronic Disease Program of the U.S. Public Health Service.[8]

One of the most active state programs of diabetes detection was that of Georgia. In 1950, in the city of Atlanta, diabetes testing was included in a multiple screening survey. All persons over age 12 were asked to participate and 210,608 individuals received a blood sugar test. The anthrone test was employed on venous blood, and the screening level was 170 mg. per 100 ml. regardless of prior food intake. Of the individuals tested, 6,786 screened positive (3.2 per cent) and were referred to physicians for diagnosis.

After the Atlanta survey, voluntary multiple health tests, including blood sugar determinations, were extended to the rest of the state. Some modifications in procedure were made. A modified glucose tolerance test was given those individuals with a positive screening test. From March, 1951, to December, 1952, 242,548 individuals were given blood sugar tests, of whom 7,804 were considered positive. After retesting, 4,109 persons (1.7 per cent) had abnormal or borderline results.[8]

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On the basis of present knowledge about the diagnosis of diabetes and field experience with screening, it is felt that screening programs can be undertaken with confidence.

An obvious place for an individual routine screening test for diabetes is in the physician's office. Outpatient departments of large hospitals and health department clinics are ideal places for the organization of a mass screening program.

Diabetes detection can be combined with established activities. For example, it has been combined successfully with mass chest x-ray surveys in several communities. Similarly, with venereal disease testing programs, blood taken may be utilized for blood sugar testing. Groups attending adult clinics in community health centers are suitable subjects for diabetes testing.

Periodic health examinations for employees and pre-employment examinations offer opportunities for diabetes detection. Diabetes detection has been carried on in many health programs of labor unions.

In a community there exist types of persons who are more likely to have diabetes than the general population, such as relatives of diabetics, parents of large babies, obese, and older persons. Case finding among such persons is very productive of undiscovered diabetes. Any community-wide program should include special appeals to such persons.

LABORATORY PROCEDURES

At present, laboratory tests afford the best opportunity for early diagnosis of diabetes, with or without symptoms. A screening test is ideally a single simple laboratory procedure which can separate out those individuals most likely to have the condition. The test procedure should be sensitive, i.e., a high proportion of the individuals with the condition should have a positive test. The

test should be specific; i.e., a high proportion of individuals not having the condition should have a negative test. The test procedure should be rapid and inexpensive.

Urine sugar tests have been widely used in diabetes programs because of their traditional use in diabetes detection and because they are rapid, simple to perform, and relatively inexpensive. The methods that have been widely used are Benedict's, Clinitest, Galatest, and Dreypak.

Recent studies, however, have shown that urine tests are relatively nonspecific and insensitive in screening, and certainly not diagnostic. Glucose may appear in the urine in diseases other than diabetes and in patients with low renal thresholds. A positive Benedict test in a urine specimen may be produced by reducing substances other than glucose. For example, this test reacts positively to glucose, fructose, lactose, and a whole gamut of other reducing substances. Conversely, patients with elevated blood sugars may not exceed their renal threshold for glucose in the early stages of diabetes mellitus and may spill no sugar in the urine. Although most diabetics do show some amount of sugar in the urine at some time during the twenty-four-hour day, it is important to note that glucosuria need not be present for a diagnosis of diabetes to be made.

The urine test for sugar has an important place in the laboratory aspect of the treatment of diabetes, but treatment is not a subject for discussion in this paper.

In recent years, blood sugar tests have been used extensively in diabetes screening, especially those procedures adapted for mass techniques. The Wilkerson-Heftmann test is such a rapid screening procedure. It uses tablet reagents. The results indicate only whether the blood sugar is above a selected level.[9] The two screening levels which are available through use of the tablets now being manufactured are 130 mg. per 100 ml. and 180 mg. per 100 ml. It is also possible to screen at 160 mg. per 100 ml. by using an especially calibrated pipette. With the use of the Clinitron, a mechanical laboratory apparatus, 120 determinations an hour can be made by this method. This is a fast procedure in comparison with other blood sugar screening methods that have been used. For example, with the standard Somogyi-Nelson, Folin-Wu, anthrone, and picric acid procedures it is estimated that a trained laboratory technician can perform about 100 determinations per 8-hour working day. An adaptation of the anthrone method for more rapid blood testing has been reported and widely used in Georgia.[10] Similarly, the picric acid method was adapted to mass detection and widely used in Alabama.[11]

The following factors should be considered in interpreting the results of blood tests:

1. *Whether blood is venous or capillary* (arterial) is important, since arterial averages 20 to 30 mg. per 100 ml. higher than venous blood after food or glucose. Fasting levels are approximately equal. Venous blood is felt to be preferable since it is less variable, and the results obtained are easily interpreted and more readily accepted in this country.

2. Since the amount of sugar in the blood is related to the *time and amount of food intake*, laboratory results within 2 hours after eating will be somewhat

higher than fasting results. Therefore, the time relationship of the blood specimen to food intake must be known, and the screening level adjusted accordingly.

3. *Method of blood sugar analysis* is important if all methods do not measure the same substance or substances. The Folin-Wu, the most widely used test, measures total reducing substances.[12] In addition to glucose, it measures non-glucose reducing substances such as glutathione, cysteine, creatinine, and ergothioneine. The Somogyi-Nelson test measures true glucose in the blood.[13] Studies of comparison of these two methods on the same blood have shown that the total reducing substances other than glucose may vary from 0 to 78 mg. per 100 ml., and that the average difference is 20 to 30 mg. per 100 ml. The anthrone method, when refined, gives a total blood carbohydrate measurement.[14] The picric acid method measures total reducing substances and is subject to the same variability as the Folin-Wu.[11]

4. *Disease states* have variable but specific effects on the blood sugar tests. Their relatively rare occurrence can be discerned upon careful diagnostic study.

5. *Method of blood preservation* is an important consideration in order to prevent glycolysis and falsely low blood sugars. There are no difficulties if a satisfactory anticoagulant preservative (such as 10 mg. of sodium or potassium fluoride per milliliter of blood) is used and the glucose analysis is carried out within two to three hours or the specimen refrigerated and the test carried out within two to three days. The effects of storage, mailing of blood, and length of action of various preservatives are still controversial and are being further evaluated.

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RETESTING

On the basis of screening experience, a procedure which includes a re-examination is recommended to provide a higher index of suspicion before referral for diagnosis and treatment. In a mass screening program, this re-examination procedure may consist of a quantitative blood sugar test between one and two hours after a high carbohydrate meal or after 50 Gm. of glucose. In borderline cases, it may be necessary to give the suspect a standard 100 Gm. oral glucose tolerance test before referral to a physician for diagnosis.

REFERRAL AND DIAGNOSIS

In diabetes detection programs, a most important aspect is the referral of suspects for further study, diagnosis, and if necessary, treatment. In this regard, the understanding and cooperation of the medical profession is essential. In several experiences reported, there was a deficiency in the type of diagnostic services received by individuals referred from diabetes screening. For example, the report of one state-wide diabetes program states that it was found through follow-up with the physician "that a simple urinalysis or a fasting blood sugar test was used to substantiate or deny the presence of diabetes in more than 76 per cent of all cases referred."[15]

Well-evaluated diagnostic standards acceptable to the medical profession are needed. At present there are a number of blood sugar methods available and a number of advocates of differing interpretations for each. Several glucose tolerance testing procedures which vary in amount, time, and route of glucose administration are in use. Amidst all the confusion there is no common agreement as to how the diagnosis of diabetes is established. This makes it especially difficult for the physician who is faced with a borderline case of diabetes.

The 3-hour 100 Gm. oral glucose tolerance test, a well-accepted procedure, seems to be the most adequate tool available for the diagnosis of diabetes. The person usually prepares for the test by eating a high carbohydrate diet daily for three successive days and then reports for the test without breakfast on the morning of the fourth day.* The standard procedure is to take blood and urine specimens fasting, and then one, two, and three hours after the ingestion of 100 Gm. of glucose in water or lemon juice.

Following are the criteria and interpretation of the 100 Gm. oral glucose tolerance test established after consultation with leading authorities in diabetes for a special study in the validation of diabetes screening, using venous blood and the Somogyi-Nelson test:

Time after glucose	*Minimum reading considered positive (mg. per 100 ml.)*
Fasting	110
1 hour	170
2 hours	120
3 hours	110

If 3 consecutive readings equal or exceed the minimum values shown above, diabetes is diagnosed. If fasting and 3-hour readings equal or exceed the minimum values, diabetes is diagnosed. If the fasting or the 3-hour reading, or both the 1- and the 2-hour readings together are positive, the case, although classified as nondiabetic, should be viewed with suspicion and restudied in six months.

EVALUATION OF DIABETES SCREENING TECHNIQUES

There are two measures which best indicate the ability of a screening test to divide a population into suspects and nonsuspects: *Sensitivity*, which means the ability of the test to classify as positive those who have the condition for which they are being screened, calculated as the percentage of those diagnosed as having diabetes who screen positive; *specificity*, which means the ability of

*The dietary preparation of the patient is one of the most widely discussed aspects of the glucose tolerance test. Many studies point out that starved persons, or those on markedly lowered CHO intake, have an abnormality in their ability to handle glucose.[16] Others have shown that this ability is restored in about 3 days in nondiabetic persons on high (300 Gm.) carbohydrate intakes.[17] It has therefore been routine to prepare patients for glucose tolerance tests by ordering carbohydrate intake of 250 Gm. for 3 days prior to the test. Many have suspected this amount to be too high. A recent study in Glasgow, comparing the glucose tolerance test after 100 Gm. CHO intake and 300 Gm. CHO intake, showed essentially no difference.[18] Further studies are being conducted to confirm this finding.

the test to classify as negative those who do not have the condition for which they are screened, calculated as the percentage of those not having diabetes who screen negative.

Experience has been gained with a variety of screening tests, levels, and procedures. These methods have been subjected to the type of evaluation that was possible under field conditions. For example, experience in Massachusetts indicated that blood sugar screening was more efficient than urine sugar screening in the detection of mild diabetes. The results of this study indicated the need for further evaluation of sensitivity and specificity of screening tests.

A screening test measuring a substance such as sugar which normally is present in varying amounts in the blood has an inherent problem. At any level selected there will be some diabetics who screen negative *or* some nondiabetics who screen positive. By setting the screening level low enough, one could ensure 100 per cent sensitivity, at the sacrifice of specificity; however, if the screening level were set high enough, 100 per cent specificity would be obtained, but the sensitivity of the test would be lowered greatly. Therefore, the selection of a "perfect" screening level is impossible, but a "good" screening level is attainable and is one which effects a practical balance between sensitivity and specificity.

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To investigate further the efficiency of diabetes screening tests, a study was carried out in the outpatient department of the District of Columbia General Hospital.[19] Venous blood samples were tested for sugar by the Wilkerson-Heftmann and the Somogyi-Nelson methods, and urine samples were tested by the Clinitest and Galatest methods. The diagnosis of diabetes was established by independent investigation in the Medical Diagnostic Clinic. To evaluate the relative effectiveness of these tests, sensitivity and specificity measures, as defined previously, were employed.

Among the clinic population screened at random times after eating, the sensitivity of the two urine tests was low. The percentage of the newly diagnosed diabetics screening positive at a trace or more was less than 40 per cent.

With a screening blood sugar level of 130 mg. per 100 ml. at random times after eating, the percentage of newly diagnosed diabetics who screened positive was low; 65.2 per cent for the Somogyi-Nelson, and 56.5 per cent for the Wilkerson-Heftmann. The percentage of nondiabetics who screened negative was 98.0 for the Somogyi-Nelson, and 96.8 for the Wilkerson-Heftmann tests. This study supplied additional evidence of the need for further investigations under more controlled conditions as to the most efficient screening levels.

A CURRENT STUDY IN DIABETES SCREENING TECHNIQUES

A study is now being carried out among the outpatient population at Boston City Hospital to evaluate screening and diagnostic tests for diabetes. This experiment is designed to solve the major problems that have arisen in diabetes screening.

Among others, one purpose of this study is to establish sensitivity and specificity ratings for the various screening methods at different levels of positivity at various times after eating.

The screening methods being evaluated are: Somogyi-Nelson, Folin-Wu, anthrone, and Wilkerson-Heftmann (on venous blood). The urine tests being evaluated are: Clinitest, Benedict's, Galatest, and Dreypak.

From patients attending the medical outpatient clinic of the hospital, persons are selected to participate in the study, provided they do not have diabetes or severe illnesses necessitating hospital admission.

An attempt is made to simulate various screening conditions, particularly in regard to time and amount of food intake. In order to accomplish this, a random blood and urine specimen are taken upon arrival at the study area. A test meal designed to approximate the average breakfast or light lunch is then given. Blood and urine samples are taken at 1, 2, and 3 hours postprandially. During this visit, a routine history, including dietary data, is taken.

From 3 to 21 days later, after a preparatory period of 250 Gm. or more of carbohydrate for the 3 successive days just prior to retesting, the individual returns for a glucose tolerance test. On this visit, a physical examination is carried out and medical history is taken.

By the criteria previously described, at the end of a year's operation, 248 individuals had been completely studied and diagnosed. By these standards 219 had been considered nondiabetics and 29 diagnosed as having diabetes. On the basis of these classifications, sensitivity and specificity ratings for the screening tests employed were set up (Table II). For example, with the Wilkerson-Heftmann test, for the random specimen before the test meal, 51.7 per cent of the newly diagnosed diabetics would screen positive (sensitivity). Almost all of the 219 nondiabetics, would screen negative; 98.6 per cent (specificity). One hour after the test meal, with the same screening level, 89.7 per cent of the diabetics screened positive and 90.9 per cent of the nondiabetics screened negative. From the experience so far, it seems that screening at three or more hours after a meal gives the poorest results. If screening is restricted to one or two hours postprandially, the test is fairly sensitive—89.7 per cent at one hour, and 69.0 per cent at two hours. The random morning specimen more often than not was taken three or more hours, and rarely within two hours, after breakfast.

If screening were limited to approximately an hour after eating with a screening level of 130 mg. per 100 ml. by the Somogyi-Nelson method, 86.2 per cent of the diabetics would have positive tests, and 90.9 per cent of the nondiabetics would have negative tests. If the screening level is raised to 150 mg. per 100 ml., only 69 per cent of the diabetics would have positive tests and 96.8 per cent of the nondiabetics would have negative tests.

A similar comparison can be made for those screened at two hours. If a level of 120 mg. per 100 ml. is used, 82.8 per cent of the diabetics would have positive tests, and 91.8 per cent of the nondiabetics will be negative. If the level is raised to 130 mg. per 100 ml., 72.4 per cent of the diabetics will be positive, and 95.9 per cent of the nondiabetics negative.

From a practical viewpoint, it appears that a screening level of 130 mg. per 100 ml. for venous blood, by the Somogyi-Nelson or Wilkerson-Heftmann methods, is an acceptable screening level if the specimen is taken one or two hours

TABLE II. SENSITIVITY* AND SPECIFICITY† RATINGS OF TWO BLOOD SUGAR TESTS FOR 29 DIABETICS AND 219 NONDIABETICS, AT RANDOM HOURS AND AFTER A TEST MEAL

(Preliminary Results)

BLOOD SUGAR LEVEL ASSUMED POSITIVE (MG./100 C.C.)	RANDOM SPECIMEN BEFORE TEST MEAL		HOURS AFTER TEST MEAL					
			ONE HOUR		TWO HOURS		THREE HOURS	
	SENSITIVITY % POS.	SPECIFICITY % NEG.	SENSITIVITY % POS.	SPECIFICITY % NEG.	SENSITIVITY % POS.	SPECIFICITY % NEG.	SENSITIVITY % POS.	SPECIFICITY % NEG.
Somogyi-Nelson Method								
90	89.7	67.6	100.0	35.6	96.6	49.3	86.2	69.4
100	72.4	88.6	96.6	55.7	89.7	70.3	75.9	86.8
110	69.0	93.6	96.6	67.1	89.7	83.1	69.0	93.6
120	65.5	96.8	96.6	83.1	82.8	91.8	62.1	97.3
130	62.1	98.6	86.2	90.9	72.4	95.9	58.6	100.0
140	51.7	99.5	75.9	93.2	69.0	99.1	58.6	100.0
150	44.8	99.5	69.0	96.8	65.5	99.1	48.3	100.0
160	34.5	99.5	69.0	98.6	58.6	99.5	44.8	100.0
170	34.5	99.5	65.5	99.1	55.2	100.0	44.8	100.0
Wilkerson-Heftmann Method								
130	51.7	98.6	89.7	90.9	69.0	97.3	51.7	99.5

*Per cent of diabetics with a positive test.
†Per cent of nondiabetics with a negative test.

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after food intake. With the use of Table II, one could select a higher screening level if a greater specificity is desired. It does not appear that screening at three hours can be made a sensitive procedure if a reasonable specificity is desired. Similar data are being accumulated on the Folin-Wu and anthrone tests. It should be emphasized that these figures are preliminary and the study continues until at least 50 previously unknown diabetics are included in the study. At present all findings must be considered tentative.

Four urine sugar tests (Clinitest, Galatest, Benedict's, and Dreypak) are being evaluated on the basis of sensitivity and specificity. If any degree of urine sugar is considered positive, including a trace, the specificity of urine tests is extremely low. Trace reactions among many nondiabetics were consistently observed at each interval studied. For example, at one hour after eating, only 46.1 per cent of nondiabetics had a negative Benedict's test, and 75 per cent of diabetics had a positive test.

If only urine sugar results of more than a trace are considered positive at screening, the specificity of the test is somewhat improved. For example, at one hour after eating, 82.8 per cent of the nondiabetics had a negative Benedict's test, while 58.3 per cent of the diabetics had a positive test. The sensitivity is considerably lower than at a trace.

If only those with 2 plus reactions by Benedict's were considered positive to screening, then 96.7 per cent of the nondiabetics would have a negative test, while 45.8 per cent of the diabetics would show a positive test.

This example of the data being collected on urine sugar screening illustrates the difficulty in trying to define an efficient urine sugar screening procedure.

SUMMARY

1. Early detection of diabetes mellitus is important for prompt institution of therapy and prevention of further progression of the disease.

2. Experience with diabetes detection has demonstrated programs to be feasible and capable of being administered by many agencies and groups. A major drawback, however, has been the lack of standardization of screening tests and their interpretation.

3. A brief discussion of the diagnostic aspects of diabetes mellitus is presented, since the final success of a screening program depends upon proper interpretation of the laboratory results.

4. It is demonstrated that through the proper use of sensitivity and specificity measures, a screening test can be adapted to the needs of the program.

5. Preliminary results in a diabetes-screening evaluation program are given as examples of methods of evaluating screening tests.

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SCREENING FOR ANEMIA AND OTHER DISORDERS OF THE BLOOD

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TO BE satisfactory, a screening test should be as simple as possible and yet accurate. It should be subject to a minimum of sources of error; and those that there are should be easily correctable.

In regard to anemia and disorders of the blood, these objectives are attainable by the collection of a few blood smears as well as 5 c.c. of venous blood in an appropriate mixture of ammonium and potassium oxalate as the anticoagulant.[1] The blood smears must be made well and stained properly. The extent to which poorly-stained and badly-prepared smears are tolerated in practice is deplorable. The physician should look upon the survey of the blood smear as being as much a part of the general examination of the patient as the application of a stethoscope to his chest. The blood smear will indicate whether there are any striking changes in the morphology of the red cells, it gives an excellent picture of the status of the leukocytes, and it also offers a rough means of estimating the quantity of platelets. In those rare instances where blood parasites are present, they can be discovered only by this means. What is most important is that the examination of the blood smear gives the clinician a little familiarity with the microscope and the laboratory and offers him an opportunity to check the latter. A poor smear may indicate similar carelessness in the laboratory procedures on which he is expected to rely.

The hematocrit provides the means for the first step in the examination of the venous blood. Except for determination of sedimentation rate, which should be done preferably within two hours of collection, venous blood can be used even 4 to 12 hours after collection if it is kept at a cool temperature. The blood having been thoroughly mixed before use by inverting its container a number of times, the hematocrit is filled with an appropriate pipet and allowed to stand in a strictly vertical position. After one hour the sedimentation rate can be read. The hematocrit is then centrifuged at a relative centrifugal force of 2,250 times gravity for one-half hour. The volume of packed red cells is then read directly from the instrument. By this means the quantity of packed red corpuscles can be determined and information can be gained regarding the existence of anemia or polycythemia much more accurately and far more easily than

by the red cell count. Above the deep-red layer of packed red cells, grayish-white and cream-colored layers of packed leukocytes and platelets, respectively, will be seen. The thickness of these layers gives a very rough idea of the quantity of these structures. The appearance of the plasma above them yields a clue to the existence of icterus, which may have not been otherwise perceived, or reveals lipemia, hemolysis, or cryoglobulins. If the blood has not been collected or preserved properly, the plasma will be red as the result of hemolysis and the sample should be discarded.

For mass screening for anemia or polycythemia the copper sulfate method for calculation of hemoglobin from specific gravities[2] is quite suitable. It has the disadvantage, as compared with the method just described, that the information derived is much more limited. On the other hand, it can be applied on a much wider scale.

The screening tests which have been outlined can be followed by diagnostic procedures, when indicated, which are also quite simple. Thus, if, from the examination of the smear or the hematocrit, there is any reason to suspect abnormality in the blood, the availability of the venous blood makes it possible to carry out several additional steps. These include the determination of hemoglobin and enumeration of the number of red cells so that the mean corpuscular volume and the mean corpuscular hemoglobin concentration can be calculated. One may also count the number of leukocytes and platelets. Venous blood is as satisfactory as capillary blood for these purposes.

Whenever there is any reason to suspect that one may be dealing with a bleeding disorder, some additional blood should be withdrawn at the time of the original venipuncture. One cubic centimeter of such blood is placed into each of three test tubes for the determination of coagulation time and, in one of these tubes, or in still another if one prefers to use a larger quantity, clot retraction may be measured. On the same occasion the bleeding time should be determined by puncture of the skin of the forearm. When one is dealing with thrombocytopenia of any substantial degree, it will usually be found that the bleeding time is prolonged and the clot retraction is poor. The tourniquet test should also be done at the same time and will be positive if there is a significant degree of thrombocytopenia. It is so difficult to count the number of platelets accurately that simultaneous determinations of bleeding time, clot retraction, and tourniquet test should be carried out.

In certain types of bleeding disorders, there may not be thrombocytopenia and the coagulation time may be normal. In such cases the simplest screening tests consist in the measurement of the one-stage prothrombin time and prothrombin consumption.[3] Prothrombin time is prolonged not only in true hypoprothrombinemia but also when there is a deficiency of Factors V or VII and in hypofibrinogenemia. The prothrombin time, on the other hand, is normal in hemophilia and in plasma thromboplastin component (PTC) and plasma thromboplastin antecedent (PTA) deficiencies. In these disorders prothrombin consumption is reduced. Prothrombin consumption is also decreased in thrombocytopenia. Still another simple step in the study of disorders of coagulation is carried out by mixing the suspected blood with normal blood and

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measuring the coagulation time and prothrombin consumption of the mixtures. If the addition of the patient's blood to normal blood causes a prolongation of the coagulation time of the latter, the presence of an anticoagulant may be suspected.

Where hemolytic anemia is suspected, the quantitative van den Bergh test and the measurement of urinary urobilinogen (2-hour test) as well as a simple test of the urine for bile are the first appropriate steps. If there is bilirubinemia of the "indirect type," increased urine urobilinogen and no bile in the urine, one should carry out the so-called three-tube presumptive test, a simple procedure designed to indicate whether or not one is dealing with cold, warm, or acid hemolysins.[4] In addition, the saline osmotic fragility test and the Coombs test are useful. A substantial increase in the osmotic fragility of the red cells is seen in congenital hemolytic disease but is unusual in the acquired types. The Coombs test is usually negative in the congenital disorder and is positive when antibodies coat the red corpuscles.[5] When there is any reason to look for sickling of the red cells, all that is required is a small drop of blood on a coverslip which is then inverted on a glass slide, ringed with petroleum jelly, and examined after 4 to 24 hours.

The procedures which have been outlined above should be available to the average physician. He can easily learn how to carry them out if he does not know already and a technician can learn to do them accurately. They should certainly be available in the laboratory of any hospital. Some of these procedures will yield clues which may require more complex laboratory techniques for the further elucidation of the case but such cases are rare. Examination of the bone marrow has not been included in this discussion deliberately, since it is a method of examination which requires more skill and training than the simple steps which have been outlined.

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BLOOD TEST SCREENING IN SYPHILIS CONTROL

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SINCE 1940, more than 200 million blood specimens have been examined for syphilis in health department laboratories. In addition, an unknown number of specimens were examined by private laboratories and other agencies such as the Red Cross. While some of these tests were made for treatment control and posttreatment follow-up, particularly in the era of arsenic and bismuth therapy, the major function of serologic testing has always been to find syphilis so as to treat those infected and thus prevent transmission of the disease, which causes disability and premature death.

Serologic testing has well served that function. During the 15 years, since 1940, 3,942,000 persons with syphilis, which was not detectable by clinical means, were reported as having been brought to diagnosis and treatment. We do not know how many additional infected patients have been found by the blood testing that served to confirm clinical diagnosis, and which resulted in treatment of patients by physicians who did not report the cases.

We are able, however, to compute the national savings which have accrued through the discovery and treatment of the almost 4 million reported patients in whom a positive blood test was the initial indication of syphilis. For example, we estimate that the progression of 469,000 patients to the stage of late symptomatic syphilis has been prevented.†

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†This estimate was made by applying findings of the Bruusgaard study[1] to the 3,942,000 persons reported as having been brought to diagnosis and treatment since 1940. The per cent of total untreated cases that would have developed late manifestations according to Bruusgaard is conservatively estimated to be 11.9, divided as follows: paresis, 79,000 (2.0 per cent); tabes dorsalis, 39,000 (1.0 per cent); meningovascular syphilis with psychoses, 20,000 (0.5 per cent); optic atrophy, 20,000 (0.5 per cent); and cardiovascular syphilis, 311,000 (7.9 per cent).

Treatment of these millions also yielded a saving of an estimated 7 million man-years* of productive earning, representing almost 14 billion dollars of income and 1 billion dollars in tax payments. The direct cost of maintenance of the 100,000 persons who would have developed syphilitic psychoses requiring institutional care would have amounted to more than 700 million dollars.

Another index, in part attributable to serologic testing, is the dramatic decrease in reported early syphilis since 1941, during which fiscal year there were reported 177,249 cases of primary, secondary, and early latent syphilis. In the fiscal year 1954, there were reported 32,687 cases of early syphilis. In addition to the early cases found directly through blood-testing surveys, interviews of survey cases resulted in finding many more early cases through the contact investigation process.

Operations in case finding on the scale described, extending over the nation and serving as a major component of venereal disease control, must be simple and relatively foolproof. They require that tests serving as case-finding devices be standardized, relatively inexpensive, adequately specific and sensitive, and, just as important, that specimens be easy to obtain by large numbers of workers. The fact that the venereal disease control program has such tests results from the significant achievements of a large group of dedicated workers.

The several applications of serologic testing used in screening may be divided into broad groups, namely, required tests, voluntary tests, and an interjacent group which might be called "protective" tests. Protective blood testing includes such measures as the routine serologic testing of a small volume of each quantity of blood donated to the Red Cross and other blood banks. It also would include routine serologic testing of all persons admitted to general hospitals in both the in- and outpatient departments. The latter screen covers approximately 2 million persons per year with an average reactivity rate of 3.4 per cent. Such programs of protective screening are certainly sound public health procedures.

"Required" blood testing includes tests legally required under Federal regulations, state statute, or local ordinance on such occasions as the physical examination prior to entrance to and separation from military service, as a prerequisite for a marriage license application, as part of a prenatal physical examination, and as a part of a pre-employment examination for certain occupations in many local communities. Although blood testing is most productive among high prevalence groups and areas in the population, syphilis does exist in all socioeconomic groups and in all geographic regions. It is therefore important that there be some case-finding mechanisms to screen persons in all groups and areas, to find hidden syphilis, and to maintain the medical and public awareness of the safeguards needed to protect the population against syphilis. Such events as employment, entrance to military service, marriage, pregnancy, and hospital-

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*This estimate of total man-years of nonproduction considers the average age when each manifestation causes disability and/or untimely death and assumes a healthy individual would have been productive through age 65. The years lost per case are as follows: paresis, 23 years; tabes dorsalis, 14 years; meningovascular syphilis with psychoses, 23 years; optic atrophy, 14 years; and cardiovascular syphilis, 12 years.

ization are especially suitable since each is associated with a need for determination of physical status.

Current estimates that 1,921,000 persons* in the United States require treatment for syphilis add emphasis to the value of the blood testing required by good medical practice on these occasions. In addition to the legally required tests for such employees as food handlers and barbers in many areas, there are many serologic tests performed in compliance with employment policies of private industry requiring a serologic test for syphilis with the physical examination for all applicants for employment. Such pre-employment tests function in the same way as legally required tests and serve to protect the health of prospective employees.

It is interesting to note the public clinics report an increasingly large proportion of persons coming to diagnosis as a result of "required" serologic testing. Thus, it would appear that as the reported incidence of syphilis decreases, required and routine blood tests (including pre-employment tests) become relatively more important as a case-finding technique. In addition to the original cases found through required serologic tests the epidemiologic techniques of contact interviewing and subsequent investigation of named contacts often are very productive. For example, a pre-employment test uncovered a sizable syphilis epidemic in the case of a "health card" applicant whose positive serologic test, found in routine examination for a food handler's permit, led to the detection of 28 additional infected persons involved in a recent syphilis outbreak in Greensboro, North Carolina.

The outstanding example of the scope, productivity, and efficiency of required or compulsory blood tests as a case-finding mechanism was the serologic examination of 15 million young men under the Selective Service Act in World War II which, in turn, had as its precursor the extensive blood testing campaigns initiated in Chicago during the late thirties.[5,6] Some 728,000 selectees with positive and doubtful blood tests were discovered, and thus more than 300,000 men who had syphilis were made available for induction into the Armed Forces. In addition to the case-finding results, a detailed statistical analysis was made of the selectees and volunteers with positive blood tests among the first 2 million men examined.[2-4] This analysis provided a unique opportunity for estimating the prevalence of syphilis in the United States at that time, and also served to pinpoint the syphilis problem by race, age, and geographic area.

One southern state passed a law in 1943 which required every resident between the ages of 14 and 50 years to submit to a blood test in an effort to locate and treat as many as possible of the individuals having hidden and undiscovered syphilis.[7,8] Due to the continuance of this mass screening effort, county by county through the years since the law was enacted, the present data show this state has made a considerable reduction of the syphilis reservoir.

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*Based on prevalence estimate of 3,282,000 from results of serologic and physical examinations of first 2 million selectees and volunteers in World War II[2-4] as brought up to date for each year as determined by the net effect of subsequent incidence, cases found and treated, and reported deaths due to syphilis. The latest estimate, as of Dec. 31, 1954, is 1,921,000 persons in the United States needing treatment for syphilis, divided about equally between those with undiscovered syphilis and those with inadequately treated syphilis.

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With the tremendous yield of persons infected with syphilis from such required blood-testing programs and the increased knowledge concerning their geographic distribution, it was a natural development to apply the same case-finding technique on a voluntary basis. Demonstration projects of mass blood testing conducted in high prevalence states were surprisingly successful.[9-12] These screening techniques, first in the annals of public health, demonstrated that large numbers of persons would gladly volunteer for a health test if this service was presented to them in an acceptable manner. These demonstration projects indicated the path that was to be followed later in applying this method to groups having a high risk. They were the pioneer projects on which, later, single and multiple purpose testing for such diseases as tuberculosis, diabetes, and other diseases was based, and the technique was rapidly applied so as to uncover large numbers of syphilis patients throughout the country.

Before discussing our experience in screening programs from the early days of mass testing to present selective survey techniques, it may be well to delineate the role of blood testing in a functioning venereal disease control program. The serologic test serves many purposes other than finding infected individuals, but it is most important in venereal disease control as a case-finding technique. There are three methods of finding persons with syphilis: blood testing, contact investigation, and using venereal disease education to motivate the diseased patient to come to treatment. They are closely interrelated. Blood-testing surveys require intensive venereal disease education to secure the support of the community as a whole and to stimulate people to volunteer to take a blood test. Subsequent interviewing of diagnosed patients for their sex contacts leads to further epidemiologic intelligence and to the discovery of new chains of infection. Thus, the syphilis case-finding program is an integrated machine with serologic screening as a basic component and with presurvey education and postsurvey contact investigation as necessary partners.

A good example of mass blood testing on a voluntary basis was the Atlanta Metropolitan Survey.[13] The entire population of Fulton and DeKalb Counties, which comprise the major portion of the Atlanta, Georgia, metropolitan area, was given the opportunity—in fact was urged—to obtain free blood tests and several other health tests. Two hundred and twenty-eight thousand persons had their blood tested. This represented about 40 per cent of the 1950 population of the area. Of the total number tested, the average rate of seroreactivity for syphilis was 9.8 per cent, which included a white rate of 1.9 per cent, and a nonwhite rate of 19.9 per cent. However, the over-all reactivity rate in a mass blood-testing program, even when considered by race, does not provide an adequate measure of the syphilis problem of a community or the productivity of the survey. For instance in Atlanta, nonwhite reactivity rates ranged from a low of 11.2 per cent in one census tract to a high of 46.1 per cent in another. Not only did the per cent of reactors vary, but the total volume of volunteers and reactive persons discovered varied greatly between census tracts.

Analyses of results of mass blood-testing surveys have shown again and again that the syphilis problem was concentrated in well-defined high prevalence areas of a city where persons in the lower socioeconomic groups were most likely

to reside. In the interest of case-finding efficiency, it was a natural development to shift program emphasis from mass blood testing to selective blood surveys. Mass blood-testing programs were gradually replaced and efforts were directed to selective testing in high prevalence areas and to socioeconomic groups at risk.[14]

Such surveys which are successful in attracting to their orbit populations with a high prevalence of syphilis require most intensive and careful planning because, after they have once begun, our experience has been that their momentum is usually so great that it is subject only to minor controls. The choice of commitments in terms of station locations, publicity, laboratory and clinic facilities, survey personnel, and channels of communication is such that the success or failure of the project has been fairly well determined in advance. Even the survey director and the local health officer can do little after the survey begins except to clear the path down which it is predestined to run, correct the minor daily errors of judgment that have been made, and capitalize on the unanticipated favorable leads that develop in its course.

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Presurvey planning must, therefore, consider all facets of the community's geography and climate, social organization, internal stresses, channels of communication, hierarchies, and talents which can affect the success of a survey adversely or favorably.[15] It must immobilize or engage each of these to achieve maximum effect in that small sector of the population which it wishes to reach. This involves attention to such details as planning the survey for hot, fair weather when sound trucks can convey their message to the largest number. It requires securing of endorsement by community leaders in governmental, medical, social, and religious life. It leads into the byways of mass entertainment media, whose facilities may be utilized to carry the message of public service in such a way as to motivate the members of those groups in which syphilis is often most prevalent to seek a blood test.

A few examples of selective screening results should perhaps be noted here. A selective survey in Pittsburgh, during the summer of 1952, tested 18,000 persons and yielded an average reactivity rate of 11.6 per cent. A reactivity rate of 15.4 per cent was found among 9,000 nonwhite persons in the Lower Hill area of Pittsburgh. The results of this survey alerted public health officials and civic leaders in Pittsburgh who did not realize the extent of the syphilis problem among certain population groups in their city.

A selective survey in New York City, in the spring of 1953, yielded an average reactivity rate of 11.5 per cent among 47,000 persons tested. Racial differences were evident in the results: white, 2.4 per cent; Negro, 14.6 per cent; and Puerto Rican, 10.4 per cent. Rates between census tracts also varied considerably.[16]

A refinement of selective testing is being developed which involves intensive house-to-house testing in limited neighborhoods or tenement blocks which are located in suspect areas of high prevalence. It is expected that this pin-pointing procedure will be even more effective in finding persons requiring treatment for syphilis.

A selective survey, in the summer of 1954, among race-track workers and agricultural migrant workers in New Jersey yielded reactivity rates of 18.1 per cent and 22.8 per cent, respectively.[17]

Selective blood-testing surveys have now become a principal case-finding technique in the syphilis control program in this country. For example, during the fiscal year 1954, there were selective surveys conducted in 136 different areas that tested 721,000 persons with an over-all reactivity rate of 7.2 per cent. This technique is the tool by means of which the estimated reservoir of 1,921,000 persons who have syphilis needing treatment will be reached and saved from the risk of premature death and disability from the late manifestations of syphilis.

Because the control effort must become more selective as persons having syphilis become more difficult to find, greater emphasis is being placed on selective blood-testing surveys to delineate areas of concentration for future activity. Concurrently such improved serologic techniques as the Treponema Pallidum Immobilization test (TPI) and Treponema Pallidum Immune Adherence test (TPIA) are becoming more readily available to assist the clinician at arriving at a definite diagnosis of syphilis on problem cases referred because of survey activity, although experience of the Venereal Disease Program has shown that under such survey conditions in high prevalence areas the false positive serologic test for syphilis has not been a serious problem. Even this problem is probably now nearer solution, for the recently reported Treponema Pallidum Agglutination test (TPA) promises to become a more useful, less expensive test using treponemal antigens which will obviate many of the technical problems incident to the uses of the other treponemal antigen tests.[18]

Until such time as most of the persons in the syphilis reservoir have been discovered and given necessary treatment, there will continue to be a need for selective blood-testing surveys. This need will extend into the future until an immunizing agent for syphilis is produced, or until the incidence of the disease approaches zero. Such selective surveys can look for syphilis only, or can be integrated into a multiple screening program.

Success of screening programs already has been demonstrated by venereal disease and tuberculosis campaigns. Public acceptance of multiple screening campaigns has been even more favorable than of those addressed to finding one or two diseases. Great accomplishments can be anticipated in the future in finding those persons needing diagnosis and treatment, as health workers develop new tests and apply them with the techniques so thoroughly demonstrated in the syphilis control program.

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SCREENING FOR GLAUCOMA

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GLAUCOMA is an insidious condition occurring most frequently among people over 40 years of age. It may affect one or both eyes and is somewhat more common among women than men. Glaucoma is not a specific disease, but the term is used to describe a group of conditions in which there is an abnormal elevation of intraocular pressure, more commonly known as hardening of the eyeball. This increased pressure, produced by a baffling interference with drainage of the aqueous fluid, gradually destroys the function of the retina and optic nerve, exerting an outward thrust at the optic nerve head at the point of entrance. By the time structural changes have taken place, much useful vision will have been lost at the sides of the visual fields and through enlargement of the blind spot.

The three most common types of glaucoma found among adults are acute congestive, chronic simple, and secondary. In acute glaucoma, the symptoms of severe pain and cloudy vision are so uncomfortable that medical attention usually is sought promptly. Chronic simple glaucoma, which is far more prevalent than the acute type, is the most dangerous, since there is a gradual painless loss of peripheral vision of which the person may be completely unaware. Glasses appear to need changing, but the new glasses do not relieve the patient's dissatisfaction; there may be occasional vague headaches and at certain times blurred or foggy vision. Secondary glaucoma, as the term implies, develops as the result of other ocular disease or following injury.

Early detection of glaucoma has long been recognized as the most important factor in preventing loss of vision from this disease, because early treatment greatly increases the likelihood of controlling pressure. It is estimated that 42,000 men and women are blind from bilateral glaucoma and that an additional 150,000 are blind in one eye. The annual incidence of blindness from this cause is estimated at 3,500 cases. Undoubtedly much of this blindness could be prevented if better facilities for discovering the disease in its early stage were generally available.

Screening for glaucoma among the general population has been found a valuable way to discover hitherto unrecognized glaucoma. Such screening has usually included ophthalmoscopic study of the fundus to detect changes

from glaucoma and other diseases and tonometry to detect a rise in tension of the eyeball. Visual acuity has usually been tested and a brief eye history taken at the same time as an aid in the recognition of possibly serious eye conditions other than glaucoma.

The first large-scale glaucoma-screening project was conducted in various plants in Philadelphia[1] among 10,000 industrial employees, aged 40 to 65 years. It was found that 20 persons could be screened each hour with qualified oculists making the examinations and assistants keeping records and testing acuities. Persons with readings on the standardized Schiøtz tonometer of more than 25 mm. of mercury were recalled for further checking; those who had such readings on more than three occasions were referred for further checking to their own oculists or to an eye clinic. Among the entire group, 153 were diagnosed as having glaucoma at the time the study was reported, an additional 71 were reported as having borderline glaucoma, and 100 more were under observation. Brav and Kirber[1] concluded that at least 2 per cent of the group had previously undiagnosed glaucoma. A significant feature of this survey was the careful social service and ophthalmologic follow-up of all suspicious cases, only 19 failing to have the diagnostic studies needed.

Among newly hospitalized patients at the Multnomah County Hospital in Portland, Oregon, Zeller and Christensen found a similar incidence of glaucoma.[2]

At the Wright-Patterson Air Force Base in Ohio, a screening of 238 persons over 40 years of age revealed 7 (2.9 per cent) with abnormally high tensions.[3] In this survey, the Berens-Tolman Hypertension Indicator[4] was used, an instrument similar to the Schiøtz tonometer but simpler in construction and giving readings at, above, or below a critical point without indicating the specific amount of tension.

Among 720 persons over 45 years of age seeking eye care in private practice, Phelps[5] found, on using routine tonometry, an incidence of glaucoma of 5 per cent.

In Cleveland, in 1953, a one-day free screening project was conducted with the cooperation of 59 oculists in 16 hospitals. A total of 12,803 persons over 40 years of age had tonometry, of whom 1,635 had tensions of 30 mm. or more on Schiøtz tonometers. Eventually, 240 persons were diagnosed as having glaucoma, an incidence of slightly under 2 per cent. Only 23 of these persons, who apparently came to the screening for a free checkup, were found later to have previously recognized glaucomas. It was not possible to obtain reports on 307 suspects.[6]

These screening studies show that properly conducted tonometric tests are a productive means of finding glaucoma among men and women over 40, and would be particularly valuable for routine use among hospital admissions and among industrial groups where the physical facilities are available for making the tests. The person being tested must lie on his back or sit with his head well back and fix his gaze on a spot directly overhead—a bright red spot fixed to the ceiling has been found helpful in attracting attention. A local anesthetic is instilled, usually 0.5 per cent Pontocaine, or 0.4 per cent Dorsacaine. There

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is a minimum stinging sensation for two or three seconds, and the tonometer can be applied in less than a minute. The proper technique of tonometry is of greatest importance, because otherwise too many false positives and false negatives result, and the cornea might be scratched. Differences in technique and in calibration of tonometers may explain the fact that in Philadelphia 11 per cent had initial tensions of 25 mm. or higher and only 5 per cent had 30 mm. or higher, while in Cleveland nearly 13 per cent had tensions of 30 mm. or higher. The local anesthetic loses its effect in 30 minutes; persons tested should be cautioned against rubbing their eyes, because if a cinder should get into the cornea in the interim considerable damage might be caused by pushing it deeper into the anesthetized tissue. In all the surveys reported so far there have been no untoward reactions, which at first were predicted, either from sensitivity to the anesthetic or from corneal injury from the tonometer or from foreign bodies. Gundersen[7] also feels that the likelihood of harm is overrated. The possibility of trouble does exist though, however remotely, and for this reason most physicians want visual acuity tests done before tonometry.

Persons with elevated tensions need careful ophthalmic studies, which sometimes take months, before a diagnosis of glaucoma can be made or excluded. Among the tests made are determinations of visual fields, gonioscopic and slit-lamp examinations, tonography, fundus examinations, and provocative tests. Since such costly studies are indicated, plans for mass screening should be made very carefully to make the tonometric examination as accurate as possible.

A new procedure which offers promise of value as a method of screening for glaucoma is the rapid visual field multiple pattern test described by Harrington.[8] In this test, a series of ten cards with abstract patterns of lines, dots, and crosses is used. A black central fixation point is visible with ordinary light, but each pattern can be seen only when illuminated with a flash of ultraviolet light for one-fourth of a second. The duration of the flash gives an adequate stimulus to extrafoveal vision, but is too short to permit a shift of fixation. Errors in describing any chart can be recorded on a composite control, and field defects quickly noted. Among a group of 250 "normal" physicians tested, 4 gave abnormal responses revealing previously unsuspected visual field defects. In 2 of the latter, the character of the defects strongly suggested glaucoma. Experience with the method in 100 abnormal patients showed a close, consistent correlation with field defects found by more thorough procedures. Because a technician can be trained to use this rapid test and no medication is needed, the method deserves further experimental use.

The importance of heredity in glaucoma has been emphasized by several investigators. Posner and Schlossman[9] reported that 14 per cent of 373 patients with glaucoma had a relative with the condition; they thus learned of 48 cases in addition to the 51 in their series, a total of 99 cases of glaucoma among 30 families. In mass screening, therefore, it is well to encourage families of glaucoma patients to have the tests and to follow up those over 40 years of age who are related to persons picked up in such surveys.

CONCLUSIONS

As the span of life lengthens, glaucoma becomes increasingly common. At present, 1 out of 8 blind persons has lost his sight from glaucoma and an estimated 1 million men and women over 40 years of age have the disease as yet unrecognized. Because of its insidious nature, glaucoma can be found in the early and more readily controlled stage chiefly by making an eye examination, including tonometry, a part of every general physical examination of those 40 years of age and older.

Results of glaucoma-screening projects, covering selected samples of the population, have established the value of this method of finding glaucoma before the person has any noticeable sign of eye trouble.

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